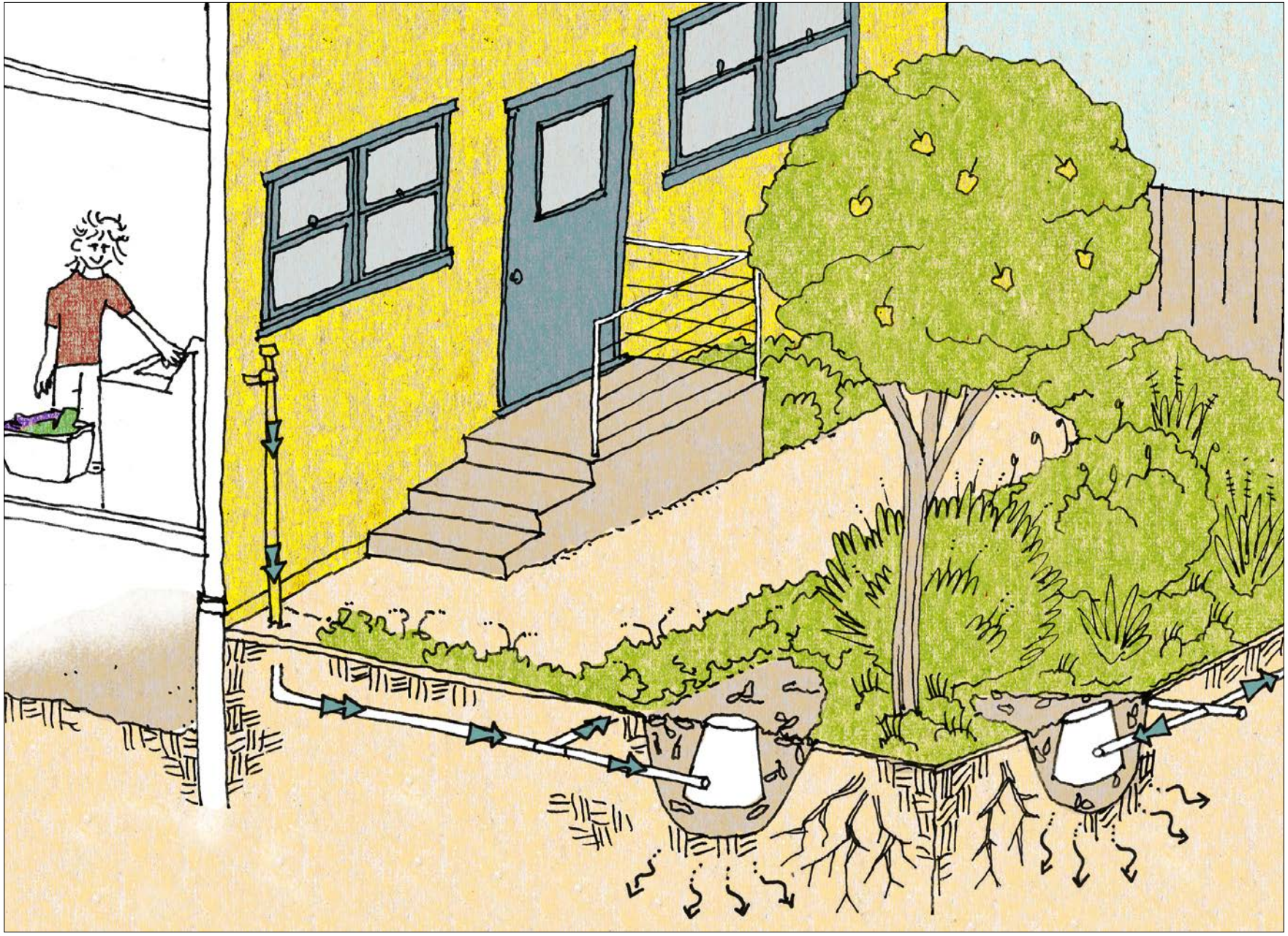

DRAFT

SAN FRANCISCO

graywaterdesignmanual

for OUTDOOR IRRIGATION

DRAFT

April 2011 Version - Updates will be published as necessary

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graywater design manual

FOR OUTDOOR IRRIGATION

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CONTENTS

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A yard irrigated with graywater. Photo: Laura Allen.

This guide gives an overview of the design, construction, permitting, and operation of graywater systems for outdoor irrigation, including laundry–to-landscape, branched-drain, and pumped systems.

Introduction

Overview of Guide

Why send your laundry water to be treated at a sewage treatment plant when you could use it to water plants and trees in your own yard instead? Sending water that's clean enough for other uses out of the house with the sewage doesn't make sense. That's why many Californians use their laundry and shower water to keep their landscapes green, even during times of drought.

The *San Francisco Graywater Design Manual for Outdoor Irrigation* is an educational resource for homeowners and professionals who want to install residential graywater systems for subsurface outdoor irrigation. In this guide, you'll learn about the benefits of graywater, when and where to use it, when not to use it, permitting requirements, what products to use, and suggested plants to irrigate.

The guide provides suggested methods for designing and installing a laundry-to-landscape system and a basic overview of the design and installation of branched-drain and pumped systems. The methods described in this guide may not be the only acceptable procedures

for designing and installing systems that meet current requirements. Each homeowner's circumstances are different: you must ensure that a graywater system on your property is designed and installed safely, is consistent with applicable code requirements, and is operated in a manner that causes no harm or damage to yourself or neighbors. If at any time you have doubts about undertaking the installation of a graywater system, please consult a professional installer or plumber.

San Francisco's Water Supply

Residents of San Francisco receive some of the highest quality tap water in the nation. Sierra snowmelt flows into the Tuolumne River, is stored in the Hetch Hetchy Reservoir, and travels 167 miles by gravity to San Francisco. The San Francisco Public Utilities Commission (SFPUC) is committed to preserving this precious resource through conservation and by using local alternative supplies—such as recycled water, rainwater, and graywater—for non-potable purposes. Using laundry water for irrigation is one of many ways to conserve our drinking water supply and reduce flows to our wastewater system.

What is Graywater?

Graywater is water from washing machines, showers, bathtubs, and bathroom sinks. It is water that contains some soap but is clean enough to water plants. Water from toilets, kitchen sinks, or wash water from diapers is not considered graywater in California.

Graywater is not the same as recycled water, which is highly treated wastewater that is used in applications such as irrigation and toilet flushing. Recycled water is commonly used in other Bay Area cities, and the SFPUC is working on several recycled water projects in San Francisco.

Benefits of Graywater

Reusing graywater is an important component of sustainable water practices. There are many benefits of using graywater instead of potable water for irrigation. Reusing graywater can:

- Decrease potable water use by 16 to 40 percent, depending on the site (Cohen 2009).

- Decrease water and wastewater utility bills.
- Diversify the City's water portfolio and provide an alternate source of irrigation water, reserving treated potable water for high-quality water needs.
- Reduce the energy (approximately 2 watt-hours per gallon of water) and chemicals needed to treat wastewater.

Another benefit of using graywater is that it connects us to our water supply, helping us understand where our water comes from and where it goes. Becoming conscious of our water supply encourages healthier product choices and engagement with our landscape. By reusing household graywater, we preserve water resources for other living things. In concert with water-wise landscaping, rainwater harvesting, and conservation, using graywater as a resource helps reduce dependency on imported water and protects watersheds.

Graywater Basics

Graywater is a unique source of water and must be used differently from potable water and rainwater. These are some basic guidelines for residential graywater systems:

- Do not store graywater more than 24 hours. If you store graywater, the nutrients in it start to break down and create bad odors.
- Minimize contact with graywater. Graywater can contain pathogens. All systems should be designed so that water soaks into the ground and is not accessible to contact by people or animals.
- Infiltrate graywater into the ground; do not allow it to pool or run off. You'll need to know how fast water soaks into your soil to properly design your system. Pooling graywater can provide opportunities for mosquitoes to breed, as well as for human contact.
- Keep your system as simple as possible: avoid pumps and filters that need upkeep. Simple systems last longer, require less maintenance, use less energy, and cost less.

- Install a valve at a convenient location to allow for easy switching between the graywater system and the sewer system.
- Match the amount of graywater directed to your plants with their irrigation needs.

Graywater Regulations

Graywater use is legal in California. In August 2009, California's graywater regulations changed, allowing for lower-cost graywater systems to be installed legally, including some without the need for a permit. In San Francisco, a permit is not required for a laundry graywater system that meets the conditions listed in the next section, "When a Permit Is Not Required." For information on systems that do require permits, see the following section, "When a Permit Is Required." California's regulations for residential graywater systems can be found in Chapter 16A of the California Plumbing Code.

When a Permit Is Not Required

You can install a graywater system **without** a permit if you meet **all** of the following requirements:

- Graywater comes from the washing machine only.
- Graywater system does not alter the household plumbing (you access graywater from the hose of the machine, not by cutting into the plumbing).
- Graywater system is for a one- or two-unit residential building.
- Graywater system follows 12 guidelines set forth in the California Plumbing Code (see Appendix B, "Operation and Maintenance Manual for Laundry-to-Landscape Graywater System").

When a Permit Is Required

You **need** a permit for a graywater system that includes **any** of the following conditions:

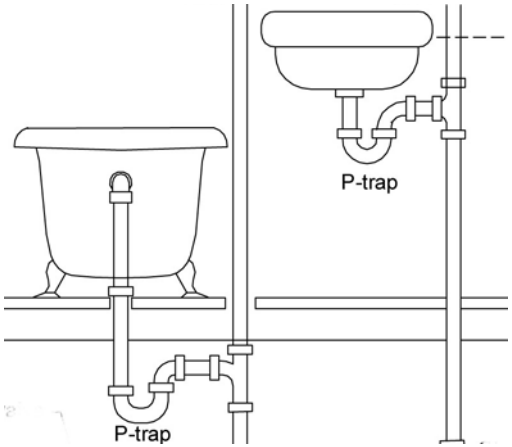
- Graywater system collects water from showers, sinks, or baths.
- Graywater system alters the plumbing (you cut into the drainage plumbing to access the graywater).
- Graywater system is installed in a building that is not a one- or two-unit residential building.
- Graywater system includes a pump (besides the washing machine's internal pump) or a tank.

References

California Graywater Code: http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf

Cohen, Yorem, 2009. Graywater—A potential source of water. UCLA Institute for the Environment. Available at http://www.ioe.ucla.edu/reportcard/article.asp?parentid=4870

The shower p-trap is the copper pipe shaped like an upsidedown and sideways letter "p." In this example, the p-trap and shower drainage pipes are located below the shower/tub. Photo: Josh Lowe.



Developing a Graywater System

Graywater systems can range from the very simple to the very complicated. Follow these steps to create a well-functioning and safe system.

1. Start with conservation! Conservation is always the most economical and environmentally beneficial place to begin. You might find that your landscape doesn't require as much water as you've been giving it, or that there are easy ways to greatly reduce the amount of water your household uses. See the SFPUC's resources for conservation information to learn about ways to save water and money.

- Before planning a graywater system, consider scheduling a free home water conservation consultation by contacting the SFPUC Water Conservation Section at (415) 551-4730 or by visiting *http://conserve.sfwater.org/*. This evaluation can help you to assess your indoor and outdoor water use and to identify ways you can lower both by fixing leaks and taking other measures.
- If you are not able install an actual graywater system, you can still reuse water by collecting shower water in a bucket as the water heats up and using it to water your plants.

2. Determine which fixtures in your home are candidates for graywater capture.

- Washing machines are usually the easiest place to begin. If your machine is in a room with an exterior wall, it's usually simple to send a pipe outside. If your machine is in an interior room, you'll need a way to run the pipe outside, either through a crawl space or basement.
- Another potential fixture for graywater capture is the shower and bathtub faucet. Identify the shower drain pipe by going beneath the shower (for example, in the basement), looking for a "p trap" (see image on left). The "p-trap" prevents sewer gases from entering the home. Run hot water in the shower and observe which pipe heats up. Make sure you do not tap into the toilet drain! A plumber can help reroute shower pipes. If your shower is on the second story, and the pipes run inside the wall, the drain is probably combined with the toilet drain in the floor, making the shower graywater inaccessible without a major plumbing remodel.

3. Estimate the quantity of graywater your chosen source produces using the "Estimating Graywater Flows" section of this manual.

4. Analyze how water drains on your site and find out your soil type with a "soil ribbon test" and/or a low cost laboratory analysis (required if your system needs a permit). In combination with your flow calculations, this analysis will help you determine how large your graywater distribution system will need to be.

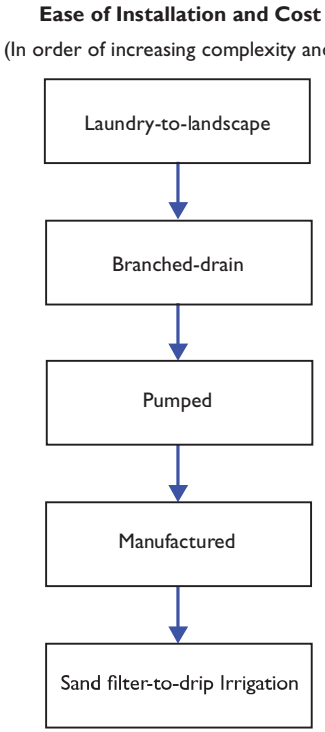
5. Read about types of graywater systems and decide which is best for you. Figure 1 provides some guidance for your selection.

6. Draw a sketch of your proposed system. If a permit is required, you'll need to submit a plot plan and details about the system to the San Francisco Department of Building Inspection.

7. Find an installer or install the system yourself.

8. Remember to label the system (3-way valve and all above-ground graywater pipes) and keep an owner's manual with it.

9. Operate and maintain your system.



System Choices, Depending on Source of Graywater

Laundry-to-landscape	Washing machine only
Branched-drain	All fixtures [1]
Pumped system	All fixtures [1]
Manufactured systems	All fixtures [1]
Sand filter-to-drip irrigation	All fixtures [2]

1 Washing machine, shower, tub, bathroom sink.

2 System typically only used for high graywater volumes.

All systems require a permit except the laundry-to-landscape system.

Figure 1. *Guidance for choosing your graywater system.*

Notes on Requirements for Calculating Graywater Flows:

For Permitted Systems: The California Code of Regulations describes a specific method that must be used to calculate graywater flows for systems that require permits (Title 24, Part 5, Chapter 16A). This method is described on page 9 of this manual.

For Systems That Do Not Require a Permit: Laundry-to-landscape systems can be sized using the method described for permitted systems OR the method described in the Irrigation Calculations section of this manual. The Irrigation Calculations section can be found on page 10.

Start by Saving Water!

Saving water is easy! You can reduce your water use by about 35 percent just by installing water-efficient fixtures and appliances. *http://conserve.sfwater.org/*

You can obtain free 1.5-gpm showerheads and possibly qualify for a rebate on a water-efficient washing machine from SFPUC. Call (415) 551-4730 for more information.

Sizing Your Graywater System

There are three steps for sizing your graywater system. It is important to follow these steps so that you can design a system that has adequate landscape distribution. Remember, state law requires that graywater irrigation systems never cause pooling or runoff.

Step 1: Estimate your graywater flows. There are different methods for estimating your graywater flows based on whether your system requires a permit or not. Follow the steps in the "Estimating Graywater Flows" section below to estimate your graywater flows.

Step 2: Estimate the soil absorption capacity of your soils based on the methods outlined in the "Soil Absorption and Distribution Area" section.

Step 3: Use your graywater flow calculations and your soil absorption calculations to calculate the necessary size of your mulch basins.

After calculating the necessary size of your landscape distribution area (as described in the next section), record this information in the operations and maintenance manual for your system (templates in Appendix B). Be sure to include the assumptions you used in your calculations. That way, if you sell your home and move out, the new owner will know how much water the system was designed for. If the new household produces more or less water, the new owner might need to make alterations to the system.

Estimating Graywater Flows

Permitted Systems

The California Code of Regulations indicates that graywater flows for permitted systems in single and multi-family dwellings can be calculated by estimates of graywater use based on water use records, calculations of local daily per person interior water use, or a default calculation method listed in the code (Title 24, Part 5, Chapter 16A). The following is the method listed in the code:

Step 1) The number of occupants in your household must be calculated as:

2 occupants in the First Bedroom

1 occupant in Each Additional Bedroom

Step 2) Graywater flows must be calculated as follows:

Showers, Bathtubs, and Washbasins: 25 gallons per day (gpd)/occupant

Washing Machines: 15 gallons per day (gpd)/occupant

Step 3) Multiply the number of occupants (as calculated above, not the actual number of people who live in the home) by the estimated graywater flow in gpd per occupant to calculate the total estimated graywater flow.

Number of occupants x graywater flow per occupant
= total estimated graywater flow

In San Francisco, you must present calculations based on this default method to DBI when you apply for a permit. However, you may be able to reduce your graywater flow calculations if you consistently use less water in your home and can produce documentation of reduced graywater production for DBI's review. Please contact DBI if you would like to make alternate calculations based on reduced graywater production in your home. Note that it is best to contact DBI early in the process so staff can assist you in creating a well-designed graywater system that works for you and future occupants of your home.

Example Graywater Flow Estimate for Permitted Systems Using the Default Code Method

In a three-bedroom house of three people, the following volumes of graywater would be produced:

Number of occupants: Four. The three person home would have four occupants using the permitted systems calculation method (two in the first bedroom plus one for each additional bedroom).

Shower graywater: 25 gpd x 4 people = 100 gpd

Washing machine graywater: 15 gpd x 4 people = 60 gpd

Total graywater produced: 100 + 60 gpd = 160 gpd

Example Graywater Flow Estimate Using the Irrigation Calculation Method

In a three-bedroom house with a laundry-to-landscape system, each person does one load of washing a week, plus there is an extra load for towels, totaling four loads per week. They spread their washing machine use out across the week, sometimes doing two loads of laundry in one day. They have a front-loading washing machine rated at 20 gallons per load.

Washing machine graywater (weekly flow): 4 loads per week x 20 gallons per load = 80 gallons per week

Washing machine graywater (daily flow): 2 loads per day x 20 gallons per load = 40 gallons per day

Irrigation during Vacations

Keep in mind that most types of graywater systems only irrigate when you are at home producing graywater. If you take frequent summer vacations or are away every weekend, you might want to have plans for back-up irrigation, or you could simply ask a housesitter to water the plants. More complex systems, like sand-filter to drip irrigation, can include back-up irrigation.

Irrigation Calculations

Can also be used to size Laundry to Landscape systems

Irrigation calculations are important to make for all systems. These calculations should be used to find out how much water is flowing to your plants, regardless of whether you have a permitted or non-permitted system. These calculations will help you ensure that your plants are not getting over or under watered.

These calculations can also be used instead of the permitted systems method to size the landscape distribution area for systems that do not require a permit. Hence, they can be used for landscape distribution sizing for laundry-to-landscape systems only. The following formulas provide guidance on making irrigation calculations.

Washing machines (weekly flow): __ gallons/load (the rating of your machine) x __ loads per week = __ gallons per week

Washing machines (daily flow): __ gallons/load (the rating of your machine) x __ loads on a typical laundry day = __ gallons per day

Showers: __ gallons per minute (the flow rate of your showerhead) x __ minutes you shower x __ showers per day x actual home occupants = gallons per day

Note that if you regularly produce higher amounts of graywater in a single day, you'll need to consider this when you design your system. Examples include multiple loads of laundry in one day or baths. You will also need to consider situations where you produce atypical amounts of graywater. If you sometimes do five loads of laundry in one day, rather than spread them out over the week, you'll need to consider this when you design and operate your system. In cases of high flows, one option is to redirect the laundry water to the sewer system using the 3-way valve. Remember you must design and operate your system to avoid graywater pooling and runoff.

Note that performing these calculations for your specific household fixtures yields the most accurate estimate of the amount of graywater available for your plants, yet does not consider future changes. Volumes could vary if the size or habits of your household change over time or if a new owner moves in.

Soil Absorption and Distribution Area

Understanding the infiltration capacity of the soils in your yard is critical for designing your graywater system and sizing your landscape distribution area. The distribution area must be sized to allow the graywater to soak into the soil without pooling or runoff.

If your system requires a permit, you must provide DBI with the results of a laboratory soil analysis to confirm your soil type. See below for details. To learn the basics about the soil in your yard, you should also conduct a simple soil "ribbon test," described on page 12.

After you have identified your soil type via laboratory analysis (required for permitted systems) and/or a ribbon test, conduct a simple drainage test to find out how well water drains on your property. This drainage test will help ensure that you choose a good location for your graywater outlets.

Laboratory Test

If your system requires a permit, you must provide DBI with the results of a soil analysis. This requirement can be fulfilled by submitting a soil sample to a laboratory for an inexpensive soil texture analysis (see Appendix F for local laboratories) or by providing an existing soil analysis to DBI. An example of an existing soil analysis is a geotechnical study done for your property. Note that the geotechnical report must be signed and stamped by a licensed engineer or geologist.

Table 1. *Identifying Soil Type Using the Ribbon Test*

Characteristics of Soil Sample	Soil Texture or Soil Type
Soil does not stay in a ball. Loose and gritty feeling when moistened.	*Sand*
A cast, or molded imprint of your fingers, forms, but it breaks easily. It does not form a ribbon. Soil feels slightly gritty.	*Sandy loam*
A short ribbon can be formed but breaks when about ½ inch long.	*Loam*
A ribbon can be formed. It is moderately strong until it breaks at about ¾ inch length. Soil feels slightly sticky.	*Clay loam*
The soil can easily be formed into a ribbon that is an inch or more long. Soil feels very sticky and gritty.	*Sandy/silty clay*
The soil can easily be formed into a ribbon that is an inch or more long. Soil feels very sticky and smooth.	*Clay*

Source: Adapted from Alameda County Waste Management Authority and Source Reduction and Recycling Board (StopWaste.org), 2010, and Thein, S.J., 1979.

Soil forms a "cast," an impression of your fingers. Photo: Josh Lowe.

Soil ribbon being squeezed between thumb and finger. Photo: Josh Lowe.

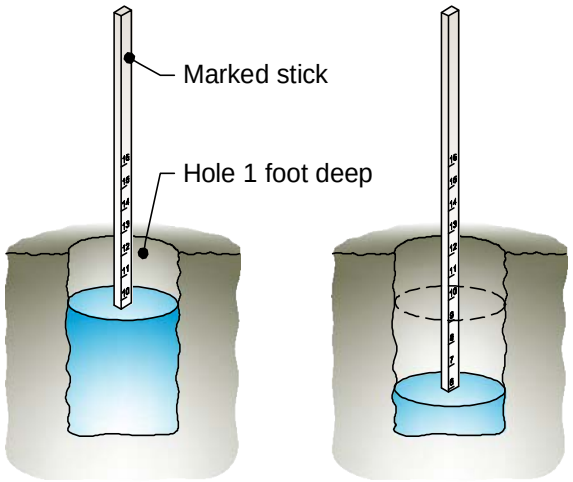


Figure 2. *Drainage test.*

Soil Ribbon Test

To conduct the soil ribbon test, take a small handful of soil in your hand, slowly moisten it with water, and knead it. Try to form the soil into a ball. Squeeze it to see if you can make a cast (an impression of your fingers). Place the ball of soil in your hand between your thumb and forefinger, gently squeeze the soil, and push it upwards into a ribbon (see image on p. 11). Let the ribbon break from its weight. Don't try to mold the soil into a ribbon by rolling it in your palms, as this will give inaccurate results. See Table 1 to identify the texture or type of soil you have.

Drainage Test

Identifying your soil type (either by ribbon test or laboratory analysis) does not always provide enough information about how well water will infiltrate in a particular location, as deeper soils could differ from surface soils, or hardscape (for example, an old cement patio) might be buried under your yard. Urban yards can be full of surprises! To ensure that water drains properly in the location you would like to irrigate with graywater, you should conduct a simple drainage test by following the steps below (Figure 2).

This drainage test is optional, as it is not required by the code. If you plan to use graywater to irrigate sections of your yard that you already irrigate, and you know that water drains well, you might not need to conduct the drainage test. If you are unsure about how water drains, the drainage test can help you choose appropriate locations for irrigating with graywater. Remember, pooling and runoff of graywater is never allowed, so if you have poor drainage with pooling, you will have to redesign your system.

1. Dig a hole, approximately one foot deep, in the area where you plan to infiltrate graywater. Insert a ruler or stick marked with inches into the hole.

2. Fill the hole with water and let it soak in. Repeat this several times so that the surrounding soil is saturated when you take your reading.

3. Fill the hole with water again; this time record how long it takes for the water level to go down a few inches. If it drains approximately one inch per hour or faster, you have adequate drainage for irrigating the area with graywater.

4. If it takes longer than two hours for the water level to go down one inch, or the hole doesn't drain all day, don't use graywater to irrigate this area. Try another location to see if the drainage is better. If you irrigate an area that does not have adequate drainage, you could have pooling and runoff. Plants could also be damaged by water-logged soil, so make sure to irrigate only properly draining soils, or amend your soil by adding compost to improve drainage.

Once you know how many gallons per day your home produces (see the Estimating Graywater Flows section), have identified your soil type (either by ribbon test or laboratory analysis), and know that water drains well in the area you wish to irrigate, you can calculate how large an area you need to ensure proper drainage of graywater.

Table 2. *Minimum Irrigation Area for Different Soil Types*

Soil Type	*Square Feet of Area Needed to Infiltrate Each Gallon of Graywater (per day)*
Coarse sand or gravel	*0.2*
Fine sand	*0.25*
Sandy loam	*0.4*
Sandy clay	*0.6*
Clay with considerable sand or gravel	*0.9*
Clay with small amounts of sand or gravel	*60*

Source: Table 16A-2, Design Criteria of Six Typical Soils, California Plumbing Code Section 16A.

Example: Calculating Minimum Infiltration or Irrigation Area

If you identified your soil type as sandy loam, you would need 0.4 square feet per gallon of graywater (Table 2). If you produce 100 gallons of graywater per day, you'd multiply 0.4 square feet/gpd by 100 gpd to get 40 square feet, the minimum area needed for your graywater to infiltrate.

100 gpd x 0.4 square feet per gpd (from Table 2)=

40 square feet of total irrigation area

This irrigation area can be spread to different locations across your yard. For example, if you want to irrigate 10 trees and your total irrigation area must be 40 square feet, each mulch basin would need to be at least 4 square feet.

This calculation does not take into consideration the appropriate amount of water necessary for the plants; refer to Appendix D-1 for plant water requirements.

Note: If your system incorporates drip irrigation, there is a different way to size the irrigation area; refer to Chapter 16A of the California Plumbing Code, Table 16A-3.

To calculate your irrigation area, you will need the following information:

•Gallons of graywater generated each day

•Soil type (to be used with Table 2)

Multiply your gallons of graywater per day by the number corresponding to your soil type in Table 2. This calculation gives you the minimum area, in square feet, needed to infiltrate your graywater.

When you design your system, make sure that the total area of your mulch basins is at least as large as the minimum irrigation area calculated above. Your irrigation area can be larger, but not smaller. Record your system specifications in your O&M manual for future reference.

Protecting Groundwater

Graywater must be discharged a minimum of three feet above the groundwater table. Groundwater occurs deeper than three feet on most of the western side of San Francisco, but some areas, especially on the eastern side, can have shallower groundwater. If you don't know how deep groundwater is beneath your property, you can check by digging a hole three feet deep. If no water enters the hole, then it is safe to irrigate the area with graywater. If water enters the hole, the groundwater table is too shallow, and graywater may not be used for irrigation. If you dig a hole to check the depth to groundwater, do so during the irrigation season, as this is the time you'll be using graywater. During the rainy months, with any signs of pooling or runoff from rainfall, or in places where the groundwater table rises, all graywater systems must be shut off.

References

Alameda County Waste Management Authority and Alameda County Source Reduction and Recycling Board, 2010. Bay-Friendly Gardening. Available at http://www.stopwaste.org/home/index.asp?page=8.

Thein, S.J., 1979. A Flow Diagram for Teaching Texture by Feel Analysis. Journal of Agronomic Education, 8:54-55.

Setback Requirements: Where Not to Put Your Graywater!

Your graywater system should irrigate plants without causing problems for you or your neighbors. A setback is a required distance between structures, such as between a building and another building, other structure, or property line. The purpose of setbacks is to avoid potential problems caused by nearby land uses. For example, you'll need to keep graywater a certain distance from your house to avoid damaging its foundation, from your neighbor's yard to maintain good neighborly relations, and from creeks to prevent contamination of freshwater. Table 3 lists setback requirements in San Francisco.

Table 3. *Setbacks Required in San Francisco*

	Minimum Horizontal Distance from	
	Graywater Irrigation Field (Feet)	*Graywater Storage Tank (Feet)*
Building structures (not including porches and steps or covered walkways, patios, driveways, etc.)	*2*	*5*
Private property lines	*1.5*	*5*
Water supply wells	*100*	*50*
Streams and lakes	*100*	*50*
On-site domestic water service line	*0*	*5*
Pressurized public water main	*10*	*10*
Water table	*3 feet above (see note 1).*	*NA*
Retaining wall[2]	*2*	*NA*

Notes:

Setbacks from the California Graywater Code, Chapter 16A, Table 1, unless otherwise indicated.

1. A test hole 3 feet deep without water can demonstrate that the site is far enough above the ground water table. The graywater system must be shut off in the rainy season.
2. Requirement specific to San Francisco.

Laundry-to-Landscape System

Description: The washing machine pump sends graywater from the drain hose out to the landscape through 1-inch tubing. The system does not alter the existing plumbing and does not require a permit. Best suited for irrigating trees, bushes, shrubs, small perennials and larger annuals.

Installation: Easy to install for the do-it-yourselfer or a professional.

Cost: Ranges from a few hundred dollars (installed by homeowner) to $1,000 to $2,000 (professional installation).

Laundry-to-Landscape System

System Overview

A laundry-to-landscape graywater system captures graywater from the discharge hose of your washing machine, enabling you to reuse the water without altering the existing plumbing in your home.

In this system, the hose leaving the washing machine is attached to a valve that allows for easy switching between the graywater system and the sewer. It is important to be able to switch to the sewer anytime you don't want to send the water outside, for example if you're using bleach, which could harm plants, or if the soil is saturated during the rainy season. The graywater is distributed through a 1-inch irrigation line with outlets directing water to specific plants (Figure 3). This system is low-cost, easy to install, and very flexible if you need to make future changes to your home or landscaping.

Parts You Will Need

You can purchase most of the parts you need from large irrigation stores; 1-inch brass 3-way valves are available from some plumbing supply stores, and complete laundry-to-landscape kits can be found online. See Appendix F for more information.

Assemble these parts:

1. 3-way valve
2. PVC 1-inch male adapter
3. 1-inch barbed male adapter
4. Hose clamp
5. PVC 1-inch x 1½-inch bushing
6. PVC 1½-inch female adapter (slip by FPT)
7. Auto vent (or air admittance valve)
8. 1-inch PVC tee
9. 1-inch barbed x slip adapter

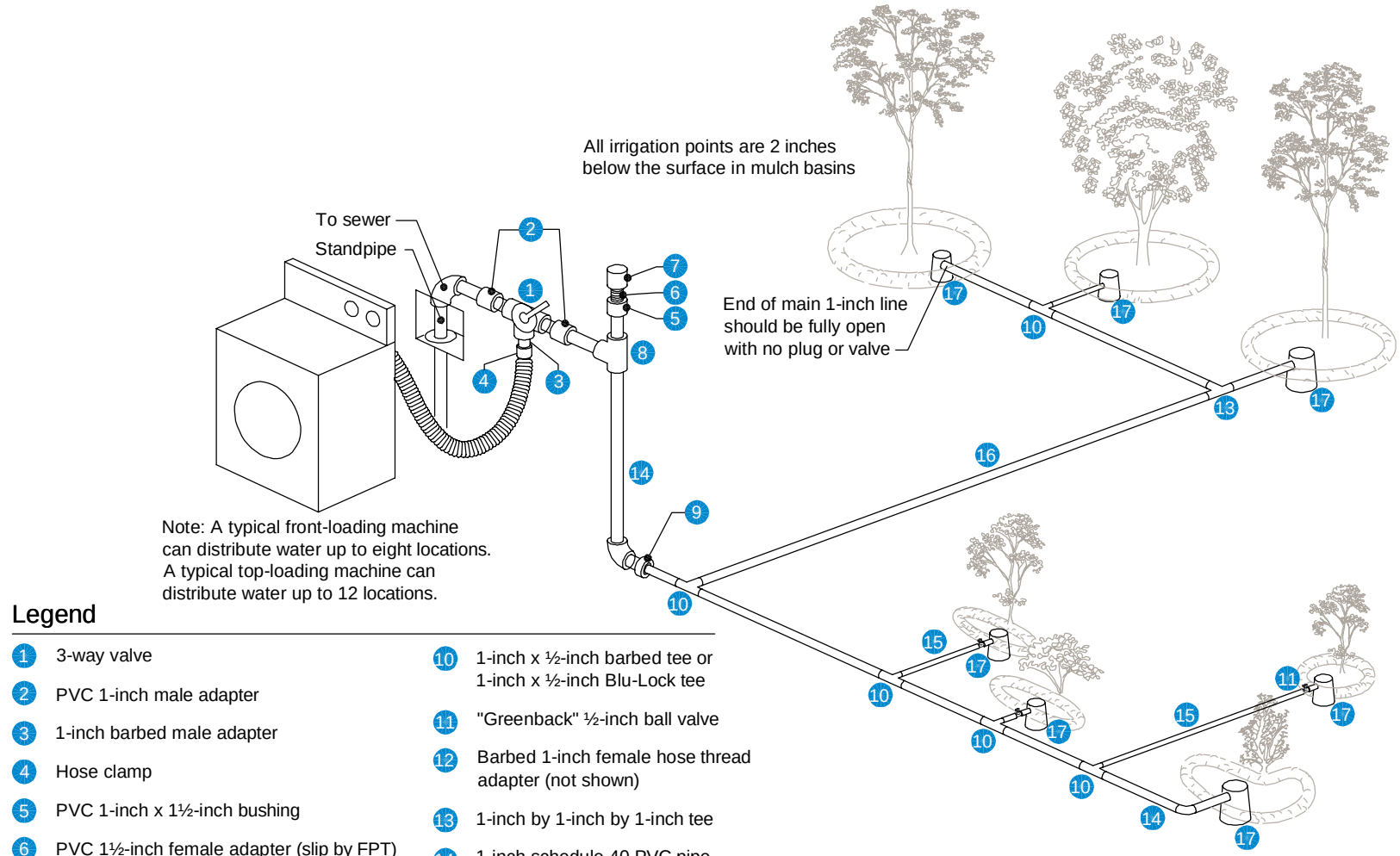
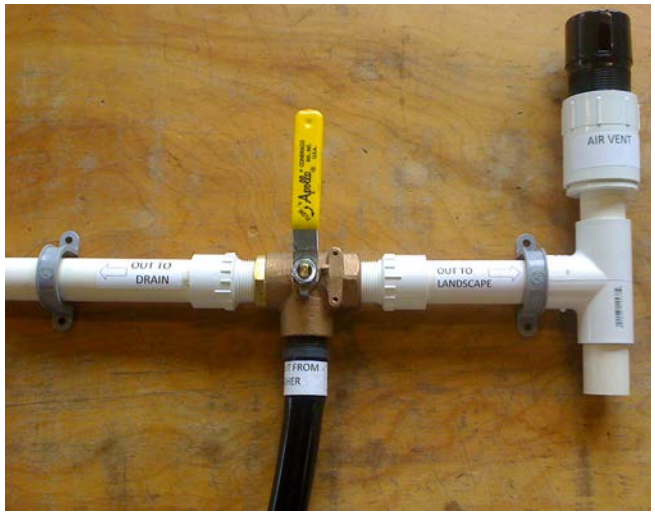


***Figure 3**. Laundry-to-landscape overview. Source: Clean Water Components.*



3-way valve for diverting laundry graywater to the landscape. Autovent shown at right. Photo: Jeff Parker.

Cleaning the Pump Filter

If your washing machine is not pumping out the water properly, the most frequent cause is objects (for example, coins or paperclips) getting stuck in the pump filter and blocking the flow of water. It is a good idea to check the pump filter before installing your graywater system. See the references at the end of this section for more information about how to clean a washing machine pump filter.

10. 1-inch x ½-inch barbed tee or 1-inch x ½-inch Blu-Lock tee
11. "Green back" ball valve (as needed)
12. Barbed 1-inch female hose thread adapter
13. 1-inch by 1-inch by 1-inch tee
14. 1-inch schedule 40 PVC pipe
15. ½-inch poly tubing
16. 1-inch HDPE tubing
17. Mulch shield or valve box
18. Garden staples

Tools you will need:

- Measuring tape
- PVC cutting tools (ratcheting cutters or a saw)
- Two pairs of channel locks
- Level
- Tubing cutters
- Drill
- 1½-inch hole saw
- ¼-inch pilot bit
- ¼-inch masonry bit (if the wall is stucco)
- Hammer
- Chisel
- Tin snips
- Shovel
- Pickaxe

How to Build a Laundry-to-Landscape System

Step 1: Assess Your Site

Where is the easiest area to irrigate? Usually this area is closest to the washing machine and not uphill. Does this area need irrigation? If not, are there more plants that need irrigation that you'd like to grow in this area? If not, is there another area needing irrigation where you could send the graywater?

Once you have identified the best place to irrigate, you'll need to figure out how to get the graywater to this landscape. Start in the laundry room. Imagine a pipe leaving the house near the machine. Is the machine on an exterior wall? If so, you'd drill through the wall to exit the building. Is the machine in an interior room? If so, is there a crawlspace or basement where you could drop down through the floor and run the pipe outside? Look for obstacles, such as doorways, sidewalks, patios, driveways, etc., on the way out. A narrow sidewalk can be cut with a concrete saw, or dug under, but a large driveway between the washer and the landscape could potentially be an insurmountable barrier.

The points below are general guidelines to help you select appropriate locations to irrigate using a laundry-to-landscape system. It is your responsibility to determine what is safe for your particular situation. If your washing machine is not operating properly or draining well, it is probably not a good idea to install a graywater system from it. When in doubt, contact a pump specialist or graywater professional.

- Sloped yards: Don't distribute water uphill. The washing machine has an internal pump, but it is not designed to pump up a hill.

  If your yard slopes downhill from the location of the washing machine, the graywater distribution piping can extend as far as needed. On steep slopes, the tubing should be installed in a serpentine pattern (S-shape, like a switch-back trail) to slow down the water. Otherwise it will rush to the bottom of the hill, and you won't be able to irrigate the upper plants.

- Flat yards: For most machines, it is generally safe to distribute graywater up to 50 feet across a flat yard. Greater distances could result in damage to the washing machine pump, since friction losses increase with distance and put more pressure on the machine's pump.

Drilling a 1½-inch hole for pipe. Note: A pilot hole was drilled first. Photo: Laura Allen.

Tightening fittings onto the 3-way valve with channel locks. Photo: Laura Allen.

Important Considerations for Exterior Walls

Exterior walls within 5 feet of the property line must be fire-rated. If your pipe exits a fire-rated wall, then you must comply with applicable building and plumbing codes to ensure that the integrity of the wall is not compromised. Consult a professional or contact DBI with questions.

Gluing pipes on either side of a 3-way valve. Photo: Laura Allen.

Draw a simple sketch of your system, from the washing machine to the plants. Collect the tools and parts needed.

Now you're ready to start building the system.

Step 2: Make an Exit for the Pipe

Identify where the pipe will exit the building. Be careful not to cut into electrical wires, pipes, or studs. Drill a ¼-inch pilot hole with a thin, long drill bit that can pass through the entire wall. Ensure you are not hitting anything in the wall. You may need to try more than one location if you hit a stud or other obstacle.

If the drill path is clear of electrical wires, pipes, and studs, and the hole exits in a good location on the outside of the building, use the pilot hole as a guide and drill with a 1½-inch hole saw to make a hole large enough for the 1-inch PVC pipe (#14). The type of bit you'll need depends on what the wall is made of: use stucco bits on stucco walls and wood bits on wooden walls. To make a clean hole on both sides, drill from both the outside in and from the inside out. After you finish installing your system, you will need to seal the hole with a waterproof adhesive, such as Sikaflex®, to prevent moisture from entering the wall.

If your washing machine is in an interior room and the pipe will exit the house through a crawlspace or basement, go under the house and look for potential obstacles. Then follow the same instructions for drilling as described above, although you only need to drill from the top down, since it won't matter what the hole looks like in the crawlspace.

Step 3: Prepare the 3-Way Valve

Note that numbers in parentheses refer to the parts list above.

1. Wrap Teflon® tape clockwise around the threaded fittings (two male adapters [#2] and one barbed male adapter [#3] fitting).

2. Insert the male adapters into the threads on both sides of the 3-way valve and turn gently, by hand, making sure not to cross-thread the plastic threads. Do the same with the barbed male adapter, inserting it into the middle of the valve. Turn

clockwise with your hands as tightly as you can.

3. With two pairs of channel locks, continue to tighten the fittings until very tight.

4. Remove the laundry drain hose from the sewer connection (utility sink or standpipe) and place a hose clamp (#4) over the end of the hose. Connect the hose to the barbed fitting on the tee and use the hose clamp to tighten and secure the hose in place, making a watertight seal. (If the hose is rigid plastic, heating the plastic can soften it and make it easier to slip over the barbed fitting. You can use a blow dryer or cup of hot water to heat the hose.) After the system is complete, you will check this seal by running the machine.

Note: These directions are written for a 1-inch laundry drain hose, which is the most common size. Some of the newer, ultra-efficient hoses are ¾-inch. If your hose is non-standard, you'll need to use a barbed fitting that fits your hose and then adapt it to a 1-inch male pipe thread fitting to attach to the 3-way valve. For example, if your hose is ¾-inch, you'll use a ¾-inch barbed male adapter threaded into a ¾-inch by 1-inch threaded bushing.

Step 4: Plumbing to and from the 3-Way Valve

1. Hold the 3-way valve (#1) up and look for a good place on the wall to mount it so that the handle can turn freely and is accessible. The valve MUST be above the flood rim of the washing machine: don't put it lower than the machine (see photo at right).

2. Choose the most direct route for plumbing one side of the valve to the sewer, and orient the other side of the valve towards the hole in the side of the house, or the floor, depending on your situation.

   Note: If your system exits through the floor, the auto vent will be inside the home, since you must put the auto vent at the high point in the system, usually directly above the hole in the floor. See Step 7 for instructions on installing the auto vent.

The 3-way valve is slightly above the sewer connection (behind the machine), while the auto vent is about a foot higher than the flood rim of the machine.
Photo: Laura Allen.

1-inch Blu-lock HDPE tubing laid out in trenches. All tubing was buried after system was finished. Photo: Laura Allen.

Mulch basin around a dwarf peach tree being filled with wood chips. Photo: David Glover.

3. Measure all the pipe pieces you need, cut the 1-inch PVC (#14), and connect the piping and fittings without any glue. Once glued, the pipe will slide farther into the fitting to a lip on the interior, so take this into account when measuring. Leave a few inches of pipe sticking out of the hole on the outside of the building.

4. Mark all of the fittings and pipe so that when you glue them together, they are in the position you would like them to be.

5. One at a time, glue the pipe sections and fittings together with PVC glue, being sure to protect underlying surfaces from dripping glue. "Gorilla PVC" is a less toxic PVC glue.

6. Go outside and glue the branch of the tee onto the pipe sticking out of the wall. While the glue is wet, adjust the tee with a level so the long axis of the tee is pointing straight up and down. Remember, if the pipe goes through the crawl space or basement, the auto vent must be located inside the laundry room. Make sure the auto vent (see next step below) is accessible so that it can be changed if it wears out and needs replacement. If water ever leaks out of the auto vent, it must be replaced.

7. The auto vent should be at least 6 inches above the flood rim of the washing machine and, when possible, located outside in case it fails and leaks. To assemble the auto vent, follow these steps. Glue the bushing (#5) into the slip portion of the 1½-inch female adapter (#6). Wrap Teflon® tape on the threads of the auto vent (#7), and then thread the auto vent into the threaded side of the female adapter (#6) and tighten. Glue one end of a small 2-inch piece of 1-inch PVC pipe (#14) into the 1-inch side of the bushing (#5). Then glue the other end into the top of the tee (#8).

8. Measure, cut, and glue a piece of PVC pipe to extend from the bottom part of the tee to the ground. If there is a deck or other obstacle between your washer and the irrigation area, you will have to route the pipe around the obstacles. Try to maintain a downward slope whenever possible. Put a 90-degree bend at the bottom of the vertical pipe section and direct the pipe towards the landscape. Place the 1-inch barbed x slip adapter (#9) on the end of the pipe. This is where the 1-inch HDPE tubing (#16) will connect.

Step 5: Preparing the Landscape and Running the Irrigation Tubing

1. Dig mulch basins around the drip line of all the plants you wish to irrigate. Mulch basins are created by removing soil and filling the empty space with mulch. If you can't dig a basin around the entire plant, dig a semi-circle, or trench on one side of the plant. The mulch basins should be between 6 and 12 inches deep, depending on the mature size of the plant. Smaller plants need less water and smaller basins.

2. Dig a trench, about 4 inches deep, from the PVC pipe to the first mulch basin. Continue the trench to all the basins, taking the most direct route possible while avoiding sharp turns. If possible, maintain a slight downward slope or at least a level gradient. If the system has dips and rises, it will be harder to get even distribution of water when you tune the system.

3. Make or buy a "valve box" or "mulch shield" for each graywater outlet (Figure 4). Mulch shields can be made out of 1- or 3-gallon flower pots. Put the pot upside down (so the bottom is on top) and make a "lid" by cutting the bottom of the pot so that it can be flipped up like a lid on a can (leaving a section intact to hold the "lid" in place). Drill a hole 2 inches below the "lid" for the graywater tube to enter. Then cut off the rest of the pot 4 inches below the hole you made for the graywater tube. If a more sturdy shield is needed, a valve box can be purchased and altered in a similar way.

4. Place each box or shield in a mulch basin. Make sure there is 2 to 4 inches of mulch underneath the mulch shield. The graywater outlet must enter the shield at least 2 inches below the ground surface.

5. Roll the HDPE tubing (#16) out in the trench to all the mulch basins, staking the tubing so it stays in place. At each irrigation point, cut the tubing and insert a 1-inch by 1/2-inch barbed tee (#10) into the tubing. Attach a short section of ½-inch poly tubing (#15) as needed to reach each basin, and insert it into the mulch shield.

6. Take a photograph of the yard before you bury the tubing! Put this picture in your operation and maintenance (O&M) manual (templates in Appendix B) for future reference. After taking the photograph, bury most of the tubing so it is securely in

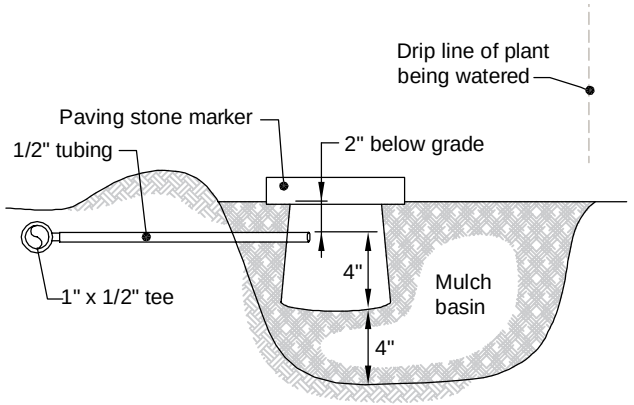


Figure 4. *Mulch shield placement.*

This 3-way valve creates two zones in the landscape. Water can be redirected from one zone to another zone by turning the handle. Photo: Laura Allen.

Adjusting flow by rotating the tees. Ball valves can be added to the ends of small tubes, if necessary.
Photo: David Glover.

place. Leave the areas with 1 x ½-inch tees (#10) exposed, as you might need to adjust them while tuning the system.

7. Multiple irrigation zones: If your site produces a lot of water and your plants are spread out in different sections of your yard, you might want to set up two irrigation zones. Having separate zones allows you to spread the water out to more places but requires someone to manually switch the system between zones. To install a second zone, add another 3-way valve at the desired location in the system, threading a male adapter by barb into each side of the tee. Run separate 1-inch tubes to different areas of the landscape. The valve directs water to each area as desired.

Step 6: "Tuning" the System

After you have laid out all the tubing, you need to test it to ensure that water flows out evenly from the multiple outlets. To do this, temporarily insert a barbed 1-inch female hose thread adapter (#12) into the tubing, where it would normally connect to the PVC pipe. Then connect a garden hose to this fitting. Turn the hose on, about medium-high flow, and then monitor the outlets. If you notice that more water is exiting the first outlet and none is reaching the end, you can adjust the angle of the tees, turning them up or down depending on whether there is too much or too little water coming out. If the flow is still uneven after you've done that, add a ½-inch green back ball valve (#11) to the first outlet and shut off the flow slightly. Do not use other types of ball valves, as they clog quickly. Is water coming out evenly among outlets now? If not, you may need to add another valve and repeat the process until water flows evenly from all the outlets. Avoid adding extra ball valves, because they are a point of potential clogging. NEVER put a valve or plug into the end of the main 1-inch line. If you restrict the end of the main line and your outlets clog, the washing machine pump could get damaged. If you have more than one 1-inch line, as when you use a 1-inch by 1-inch by 1-inch tee, and send two 1-inch lines in different directions, then it is okay to restrict one end, since there is a second end fully open.

Step 7: Testing the System

After you have tuned the part of the system outside your home, disconnect the hose and connect the tubing to the PVC pipe. Now you'll test the system with the washing machine. Run a load of laundry with the 3-way valve turned to the graywater system. As

the water flows out, check the glued joints, making sure they are all watertight. Check the connection from the washer hose to the 3-way valve; this is a common place to have leaks. You might need to tighten the hose clamp or add a second clamp. Next, go outside and observe how water flows through the system. You might need to readjust the ball valve(s), since the water pressure from the machine will be different from that of the hose. After testing is complete, paint exposed PVC pipe with regular house paint, usually the same color as the building (to protect it from UV damage), and waterproof any holes.

Step 8: Labeling the System

Label the 3-way valve and aboveground graywater pipes (Appendix A). The 3-way valve must be labeled with clear instructions for changing the direction of graywater flow (to sewer or landscape). Aboveground pipes must be labeled with the words "CAUTION: NONPOTABLE WATER, DO NOT DRINK" at intervals of 5 feet or less.

Key Points

- Put the 3-way valve above the flood rim of the machine, in an accessible location inside the home.
- Put the auto vent at the high point of the system, at least 6 inches above the flood rim of the washing machine in an accessible location in case it needs to be replaced. If possible, locate the auto vent outside.
- Use 1-inch pipe and tubing, with 1-inch x ½-inch tees to send graywater to specific plants; do not use larger or smaller pipe for the main graywater line.
- Always leave one end of the 1-inch main line tubing fully open, with no valves or caps.
- Don't overwork your washing machine. Remember not to use the pump to send water uphill or too far across a flat yard (50 feet across a flat yard is typically a safe distance).

Exposed PVC pipe is painted to protect it from UV degredation. The hole is sealed with an adhesive sealant to prevent moisture from entering.

Operation and Maintenance

A summary of O&M activities is presented in Table 4. Templates for O&M manuals are provided in Appendix B.

Table 4. *Laundry-to-Landscape System: Operation and Maintenance Checklist*

Component	Inspection Schedule	O&M Activity	Action Needed
3-way valve	Annual	Check for leaks at washer hose and that label is in place	☐ Condition good ☐ Action needed • If leaking, tighten hose clamp. • Replace label if needed.
Auto vent	Annual	Check for leaks from auto vent	☐ Condition good ☐ Action needed If leaking, replace the auto vent.
Piping and tubing	If you notice water in an unusual place	Check for leaks	☐ Condition good ☐ Action needed If piping or tubing is damaged, cut out damaged section and reconnect with a 1-inch barbed coupling.
	Annual	Check for even distribution from outlets	☐ Condition good ☐ Action needed Unclog hair or lint built up in the outlets. Open ball valves, check for clogs. If needed, flush the system with a hose: temporarily disconnect the tubing from the PVC fitting, attach the garden hose by barb fitting, and connect the hose to the system.
Mulch basins	Annual	Check to see if mulch has decomposed and water is pooling under graywater outlets	☐ Condition good ☐ Action needed Remove decomposed mulch and add new mulch.

Second Standpipe Option for Laundry Machine Graywater

Another option for a washing machine system is to install a second standpipe next to the existing standpipe (Figure 5). A standpipe is a vertical pipe into which the washing machine hose discharges. The existing standpipe should be plumbed to the sanitary sewer. The second standpipe can be plumbed to a graywater irrigation system.

In a second standpipe graywater system, the exterior graywater irrigation system should be identical to the branched drain system described in the section titled "Branched Drain System." There is no 3-way valve inside the house at the washing machine, and the hose from the washing machine is moved manually from one standpipe to the other. The second standpipe method adds no extra strain on the washing machine pump. If your machine is old or has any problems, and you are worried that a laundry-to-landscape system might not be good for the machine, you can install a second standpipe graywater system instead. This method does make it harder to distribute the water to plants than the laundry-to-landscape system, because it is a gravity-based system and does not take advantage of the washing machine's pump to distribute graywater.

The second standpipe option does not require a permit as long as the graywater system is for a one- or two- unit residential building and follows the 12 guidelines set forth in the California Plumbing Code (see Appendix B).

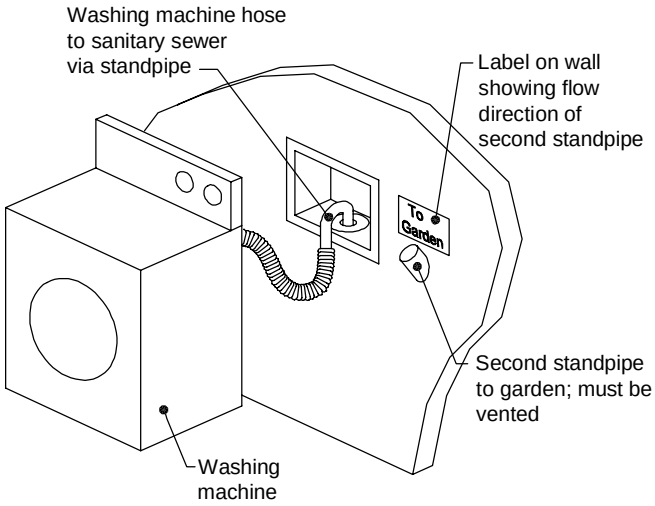


Figure 5. *Second standpipe option.*
Source: City of Berkeley.

References

Create an Oasis with Greywater 5th Edition: http://oasisdesign.net/greywater/laundry/index.php

How to clean the filter of your washing machine pump: http://www.ehow.com/how_6161420_clean-front-load-washing-machine.html

DRAFT

Branched-Drain System

Description: Graywater drains through a series of branching pipes and is dispersed into the landscape via mulch basin outlets. This system alters the existing plumbing and requires a permit. Branched-drain systems are typically installed on shower drains and/or sinks. The graywater irrigation zone must be downhill relative to the graywater source. A branched drain system is best suited for irrigating trees, bushes, shrubs, and other larger perennial plants.

Installation: Installation difficulty varies greatly depending on the existing household plumbing. A solid understanding of plumbing is needed, as well as basic landscaping skills. Installation is more time-consuming than for a laundry-to-landscape system.

Cost: Costs can range from a few hundred dollars (installed by homeowner) to a few thousand dollars (professional installation).

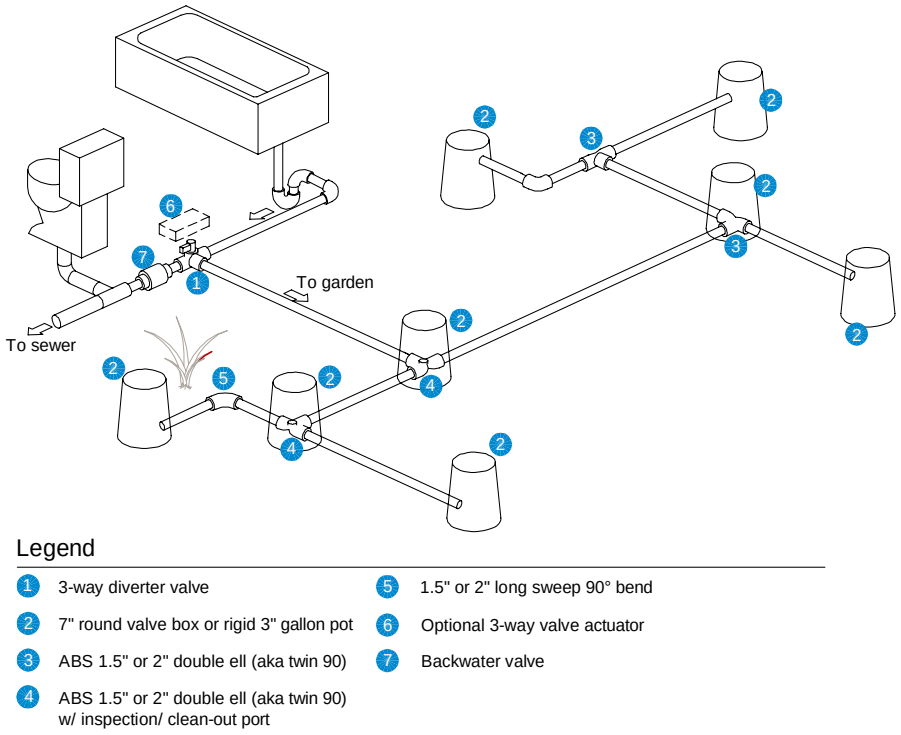


Figure 6. *Branched-drain system. Source: Cleanwater Components.*

Branched-Drain System

System Overview

A branched-drain system allows a homeowner to use graywater from other sources besides the washing machine. The system is simple and requires no electricity. A branched-drain system is driven by gravity flow; no pressure is provided by a washing machine pump or any other pump. This type of system usually distributes graywater from showers and/or sinks, although it is also used in the second standpipe system described earlier. A branched-drain system distributes graywater to the landscape using standard 1½-inch or 2-inch drainage pipe (Figure 6). The irrigated area must be lower in elevation than the graywater source, and the entire distribution system must have a downward slope of 2 percent (¼ inch per foot). The graywater is divided, or "branched," using double-ell flow splitters (also called twin 90s), and the final outlet of each "branch" irrigates the root zone of a plant via a mulch basin. Branched drain systems are best suited to irrigating trees or large shrubs. This kind of system can be time-consuming to construct, but once complete, it requires little maintenance and lasts a long time, since it has no moving parts to break.

How to Build a Branched-Drain System

Note that the following description provides a basic outline of the steps for installing this type of system, but you will need to consult other resources when you plan and install your system.

1. Assess your site: Identify the graywater pipes (shower, sink, or laundry) and make sure that you can access them and install a 3-way valve before the pipes combine with the toilet drain. Think about how the pipe could be directed to your landscape, considering obstacles like driveways or patios. Identify appropriate plants to irrigate: this type of system is best for trees, shrubs, vines, and other large perennials.

2. Obtain a graywater permit from DBI. See Appendix E for more details.

3. Install a 3-way diverter valve in the drainpipe of the fixture you will be collecting graywater from (Figure 7). The valve must be installed after the p-trap and vent but before the connection to a toilet or kitchen sink drain. If you must install the valve in an inaccessible area because of space considerations, for example, in a small crawlspace, you can add a motor (called an actuator) to the valve and connect it to a switch in the bathroom or other convenient location.

4. Plumb the graywater pipe to your landscape, following standard plumbing techniques, strapping, maintaining a ¼-inch-per-foot gradient, using clean-outs (pipe fittings with a removable plug to allow access to the interior of a pipe, for example, for removing clogs) when needed, and properly sealing the hole you created to exit the building. When exiting the building, make sure not to damage electrical, gas, or plumbing pipes that could be located in the wall, and avoid structural beams and the house foundation. If you have any doubts about plumbing and/or drilling through floors or walls,

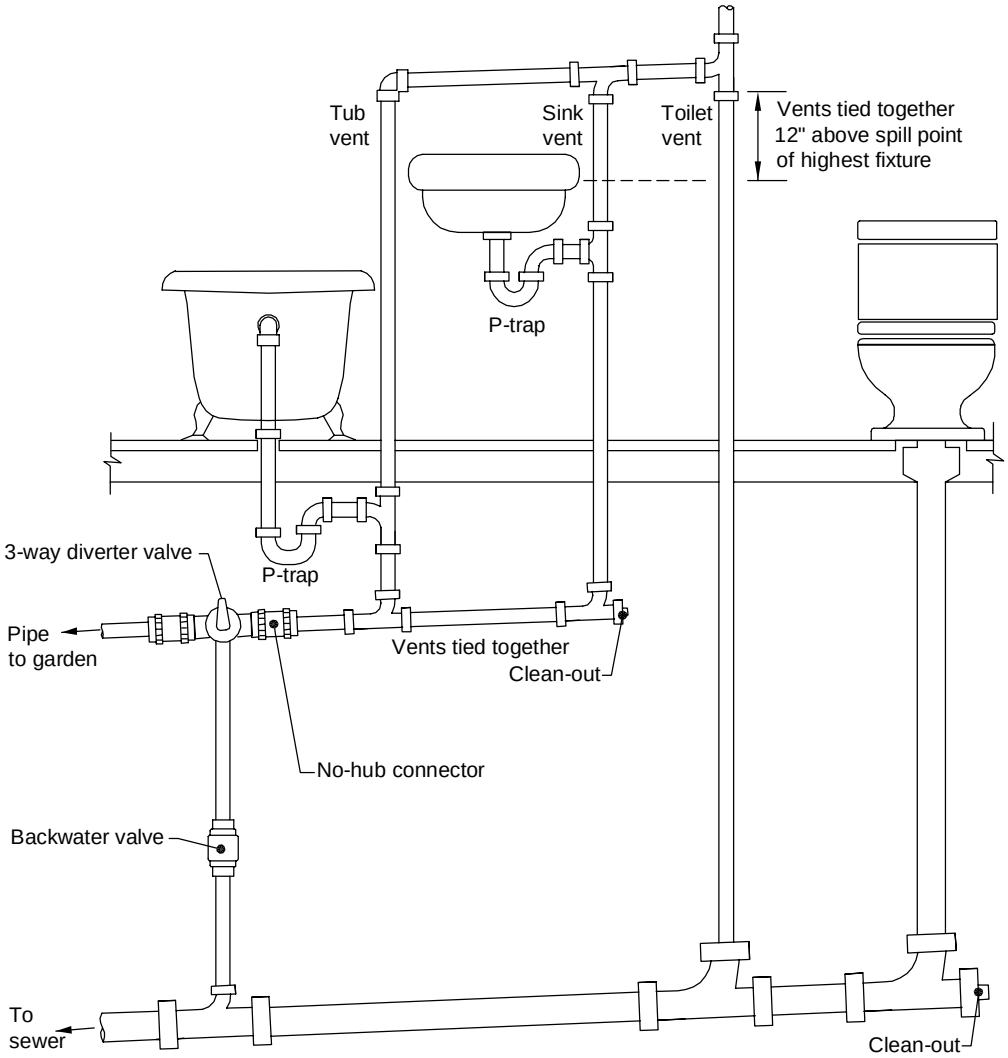


Figure 7. *Location of the 3-way valve in a shower or sink system. Source: Art Ludwig, Oasis Design.*

call in a professional! Chapter 7 of the California Plumbing Code contains the drainage plumbing requirements that must be followed when you install the system.

5. Prepare the landscape: dig mulch basins around the drip lines of the plants to be irrigated, trench the pipe to the plants, and construct mulch shields for subsurface irrigation (Figure 8). Make sure that the graywater is discharged at least 2 inches below ground surface and that it falls through the air onto 4 to 6 inches of mulch.

6. Test the system by turning on the fixture(s), making sure that the graywater flows properly.

For more information about how to install a branched-drain system, see the book references in Appendix F.

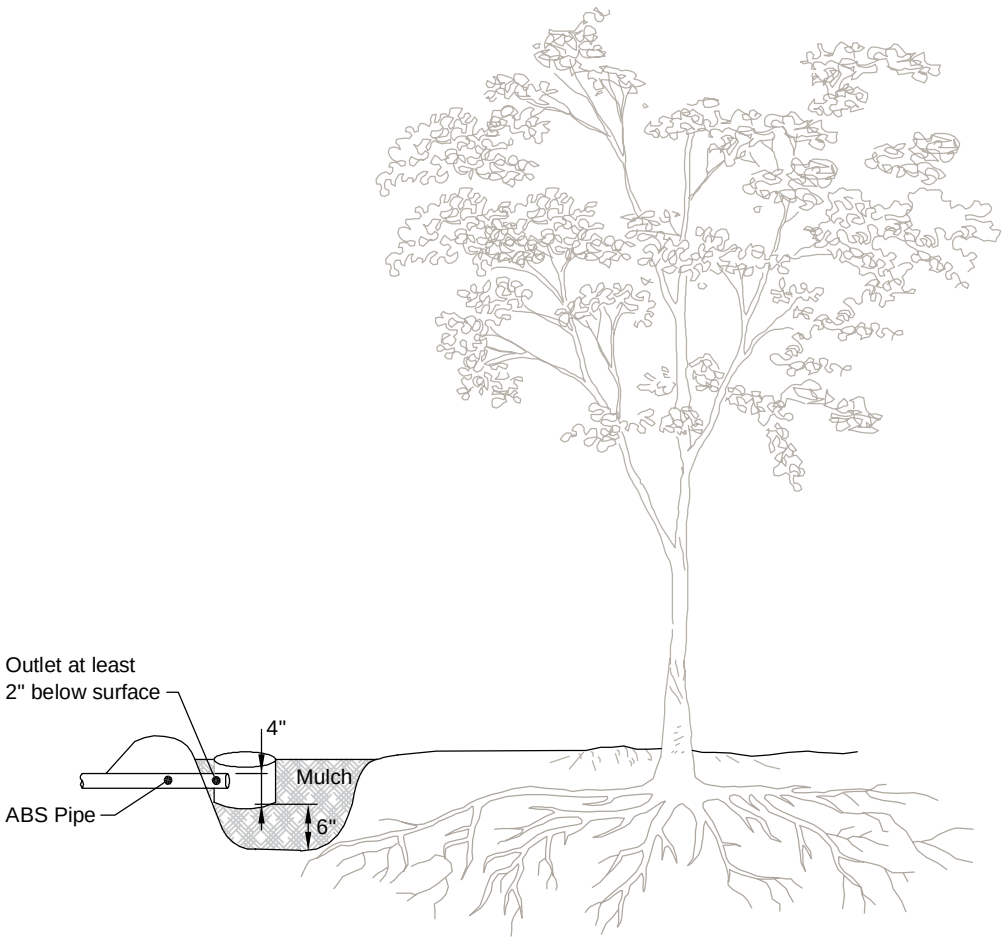


Figure 8. *Mulch shield inside of mulch basin. Note: Roots of a real tree would extend under basin and outside of drip line by many feet.*

Pumped Systems

Electricity and Water in California

In California, almost 20 percent of all electricity and over 30 percent of natural gas is used to pump, heat, and treat water. Graywater systems sometimes need to incorporate a pump, but the homeowner should carefully examine non-pumping options first to minimize the use of electricity. Pumped systems are most often installed when irrigation is needed uphill of the graywater source. Pumped systems can also be installed to pressurize graywater for a drip irrigation system, in which case the water must be filtered.

Overview of Pumped Systems

In pumped systems, graywater is directed to a temporary holding tank before being pumped to the landscape. If the system is to be used for drip irrigation, the graywater must be filtered before it reaches the drip emitters (see description of Sand Filter-to-Drip Irrigation system in the next section). The pumped system described below does not include filtration and therefore can only be used for sending graywater uphill, not for drip irrigation.

Pumped System with No Filtration

As illustrated in Figure 9, in a pumped system with no filtration, also referred to as a "drum with effluent pump system," graywater is directed to a watertight tank (also called a surge tank), from which an effluent pump

Pumped Systems with No Filtration

Description: Graywater from showers, sinks, or laundry is directed to a temporary holding tank and then pumped to the landscape, which can be uphill of the graywater source(s). This system usually alters the existing plumbing and always requires a permit; an additional electrical permit might also be required for the outlet that the pump is plugged into. These systems are best suited for irrigating perennials of any size and larger annuals. An example is corn.

Installation: Installation difficulty varies greatly depending on the existing household plumbing. A solid understanding of plumbing is needed, as well as basic landscaping skills. If a new electrical outlet is required, electrical skills are also required.

Cost: Costs can range from $500-$700 (installed by homeowner) to a few thousand dollars (professional installation).

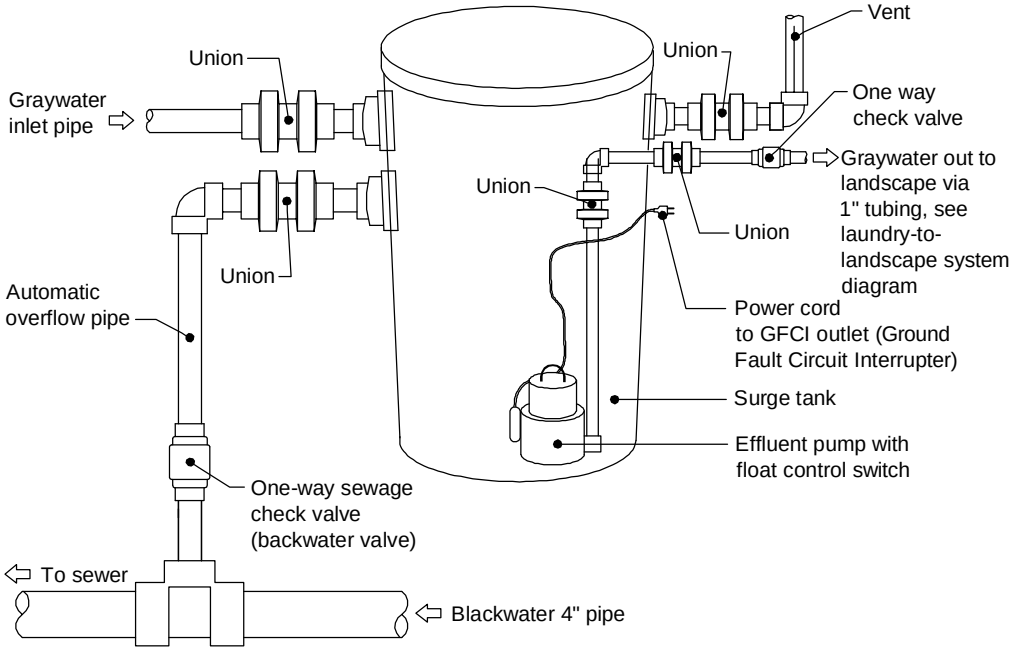


Figure 9. *Drum with effluent pump.*
Source: Robert Kourik, in Drip Irrigation for Every Landscape and All Climates.

discharges water through tubing to the landscape. This system is lower in cost and easier to install than a system that includes a filter for drip irrigation, but it is less water efficient since the outlets are larger.

It is possible to put in simple filters to capture hair and lint "upstream" of the surge tank, thus reducing the power required of the pump, but the filters need to be cleaned regularly. Cleaning a graywater filter is a smelly, slimy, and generally unpleasant task that is often left undone, leading to clogged filters, possible graywater overflows, and other undesired consequences. Systems with filters requiring manual cleaning tend to have a higher failure rate than systems that don't require filters to be cleaned manually.

How to Build a Pumped System with No Filtration

Once you have determined that pumping the graywater is the only possible way to reach your landscape, the steps below provide a general overview for installing a simple pumped system with no filtration. Note that you will need to consult additional resources to build the system. Keep in mind that a pumped system is more complicated than the systems described previously

1. Assess your site: Identify the graywater pipes (shower, sink, or laundry) and make sure you can access them. Identify a location for the surge tank and an outlet to plug in the pump. If there is an existing outlet nearby, you'll need to determine if the outlet can handle the additional electrical load of the pump. If you are unsure how to determine this, hire a professional. If you need to add an electrical outlet, an electrical permit will be required.

2. Apply to DBI for a graywater permit and for an electrical permit, if a new outlet or dedicated circuit is needed for the pump.

3. Install a 3-way diverter valve in the drain line of the desired graywater fixture, after the p-trap and vent but before the connection to a toilet or kitchen sink drain.

4. Install the surge tank and route the graywater to it. Check the California Plumbing Code for requirements for how to outfit the tank. Requirements include a union fitting, vent, overflow pipe with a backwater valve, and a swing-check valve on the graywater pipe exiting the tank. Graywater may not be stored for longer than 24

hours, so size the tank so that it empties at least once a day.

5. Direct the irrigation line to the landscape using 1-inch tubing and reducing tee fittings at each plant. See Figure 3 for the laundry-to-landscape system for more details.

6. Prepare the landscape: dig mulch basins around the drip lines of the plants to be irrigated, trench the pipe to the plants, and construct mulch shields for subsurface irrigation.

7. Test the system by turning on the fixture(s), making sure that the graywater flows properly, the pump turns on when it should, and graywater is distributed evenly to the landscape.

Materials needed for a pumped system:

- 3-way valve
- ABS fittings
- Tank
- Effluent pump rated to pump ¾-inch solids
- Unions
- Backwater valve
- Swing-check valve
- 1-inch tubing
- Barbed fittings with ½-inch outlets
- Mulch

For more information on pumped systems, see the references in Appendix F.

Graywater sand filter at the Sunset San Francisco Idea House.
Photo: WaterSprout.

Sand Filter-to-Drip Irrigation

Description: Graywater flows by gravity to a temporary holding tank, is pumped through a sand filter to remove particles, and then is pumped to a drip irrigation system. An irrigation controller allows municipal water to supplement graywater as needed and also controls automatic cleaning of the filter. This system requires a permit for graywater and could require an electrical permit as well. In addition, a backflow prevention assembly must be installed on the municipal water supply line, and the assembly must be tested annually. This system is suitable for all plants, except for lawns.

Installation: Sand filter to drip irrigation systems must be installed by a professional.

Cost: System costs range from $7,000 to $15,000 (professional installation).

Other Graywater Systems

In addition to the systems described previously in this manual, there are other options for designing and installing more complex graywater systems. Some of these options are briefly discussed below. New construction or full plumbing remodels can give you access to more graywater sources than are typically available in a retrofit situation. With a larger volume of graywater available, more complex options might be appropriate for your situation. These systems are usually more expensive, can distribute water to more locations, and are a more water-efficient way to irrigate. Complex graywater systems are typically found in high-end residential new construction, especially houses seeking LEED accreditation. Such systems always require a permit.

Dual Drainage Plumbing

If you are building a new house or doing a major plumbing remodel, you can ask the plumber to keep the graywater drains separate from the toilet and kitchen sink drains, enabling you to access all the household graywater in one pipe. This is dual drainage plumbing. In this scenario, the graywater and black water (toilet and kitchen sink) pipes can combine either after they exit the house or "downstream" of a convenient location for installing a 3-way valve on the graywater pipe.

Sand Filter-to-Drip Irrigation

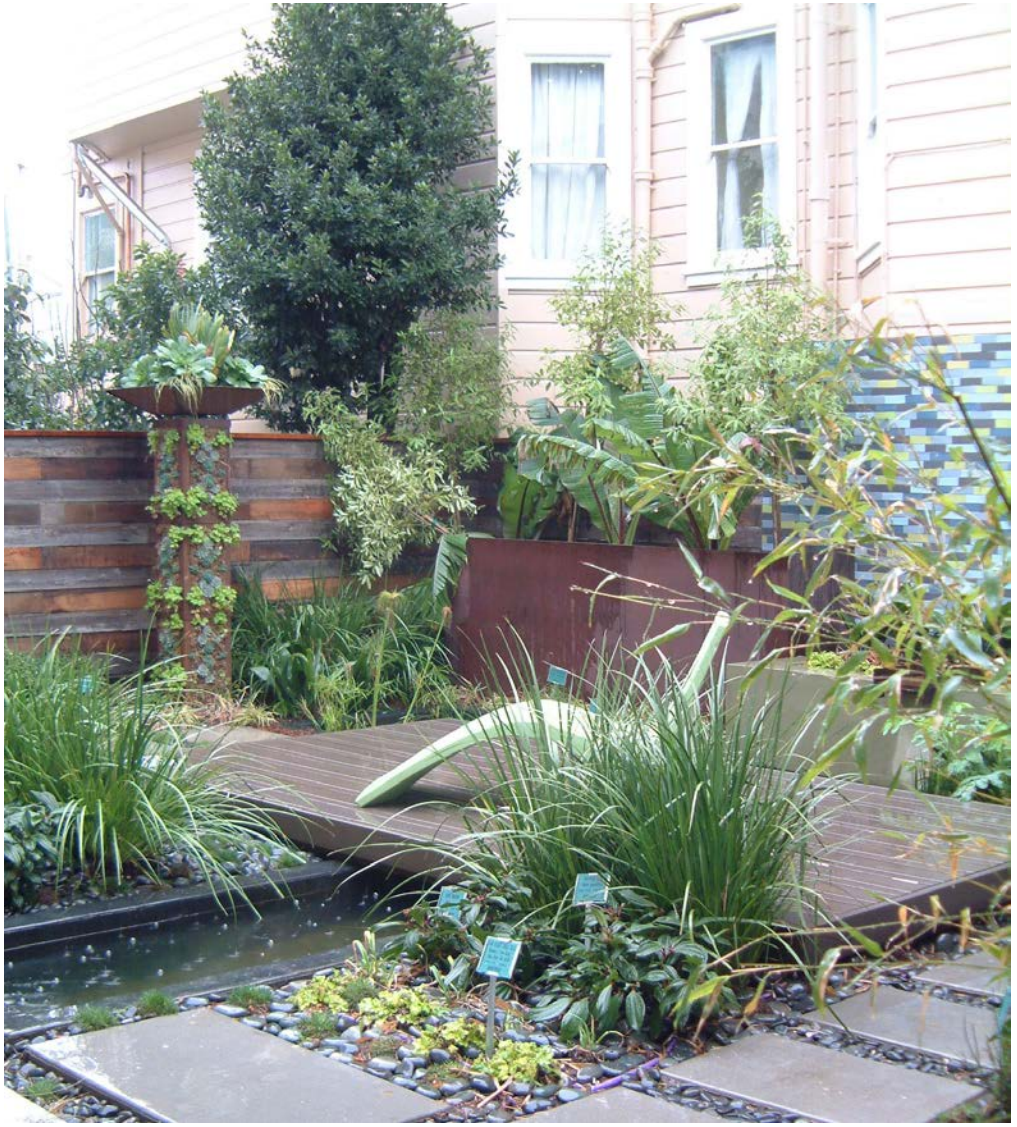
Drip irrigation is the most water-efficient form of landscape irrigation. For graywater to be used in a drip irrigation system, the dirt, hair, and lint must be filtered out so they won't clog the drip emitters. Graywater for drip irrigation is commonly filtered with a sand filter. Note that sand

filters only remove solids, not salts or chemicals, so it is still important to use graywater-friendly cleaning products (Appendix C).

In a sand filter-to-drip irrigation system, all the graywater from the house is plumbed to a holding tank, where the graywater is temporarily stored. An irrigation controller turns on an effluent pump in the holding tank when irrigation is needed. The pump sends the graywater through a sand filter, where the dirt, hair, and lint particles are filtered out. The filtered graywater then goes to drip irrigation tubing in the landscape. If there is not enough graywater, the system is set up to include municipal water. This type of system is fully automated and thus more complex and higher in cost than simpler systems, but it allows for greater flexibility in irrigation and can irrigate plants of any size and elevation relative to the house. The sand filter is cleaned automatically on a timed schedule: pressurized municipal water is sent backwards through the filter to remove debris, with the effluent water directed to the sewer. A reduced pressure principle backflow prevention assembly must be installed to protect the municipal (potable) water supply from accidental contamination with graywater. This assembly must be tested by a licensed tester on an annual basis and the results sent to the Water Quality Division of SFPUC.

Manufactured Graywater Systems

It is also possible to purchase manufactured graywater systems. Most companies that provide these systems are relatively new, so it is important to research the system you are considering. It would be wise to talk with someone who has owned and operated the system (and not just a sales person or the inventor) for at least a year. Because these systems incorporate filters, pumps, and often disinfectant,



This landscape is irrigated with graywater that has passed through a sand filter before entering the subsurface drip irrigation system. Note: The pond is not supplied by graywater and is lined so that graywater doesn't enter it. Photo: WaterSprout.

they have more components to maintain and replace. It is also important to find out the system's maintenance needs and learn how you'll know if the system isn't working properly. Systems that require regular manual cleaning of filters may not be a lasting solution, since human forgetfulness can easily create a system failure.

Indoor Use

In theory, graywater can be filtered, disinfected, and pumped back inside residential buildings to be used for toilet flushing and other non-potable uses. In practice, doing so is not very easy. There are currently a rigorous set of water quality standards which need to be met for interior graywater reuse (California Code of Regulations, Title 22, Section 60301.230). While technology has been developed to meet these standards, the technology can be expensive for individual homes. Many of these systems also have kinks that need to be worked out.

Currently, it may be easier for most households to use rainwater for toilet flushing and graywater for outdoor irrigation. Composting toilets are another water-smart option, although having at least one flush toilet is required by law.

Glossary

3-way diverter valve A valve that directs water in one of two directions: the sewer or the landscape. Diverter valves come in different materials and sizes.

ABS Acrylonitrile butadiene styrene, a black plastic pipe used in drainage plumbing. ABS pipe is used in gravity-based graywater systems, such as branched-drain systems. ABS is cut with a saw or tubing cutters and glued together with ABS glue, also called ABS cement.

Actuator A motor that attaches to the face of a plastic 3-way valve and connects to a plug-in transformer and a toggle switch so that a graywater system can be turned on or off from another location (usually inside the house).

Auto vent (also called air admittance valve, AAV, Studor valve, in-line vent) A device that allows air to enter a drainage plumbing system. In a graywater system, it prevents water being "sucked out" or siphoned out of the washing machine while it is filling. The auto vent must be located at the high point of the graywater system. This device must not be installed on the plumbing system of the house or unit, as this is not allowed under the San Francisco Plumbing Code.

Backflow preventer An assembly that prevents water from reversing its flow direction. Backflow preventers are used to protect the municipal water system from contamination, for example, by graywater from a sand filter-to-drip irrigation system. Backflow preventer assemblies must be tested annually by a licensed tester to ensure they're working properly. A reduced pressure principle backflow preventer (RP) is required for graywater systems that include municipal make-up water and do not have an air gap.

Backwater valve A type of swing-check valve used on the overflow pipe of a graywater tank. Its purpose is to prevent sewage from entering the tank in the event of a sewage clog.

Ball valve A device that shuts off the flow through a tube or pipe when a "ball" is turned inside the valve.

Barbed fitting Fitting used in the irrigation part of a laundry-to-landscape system. The tubing fits over the barbs and can be forcibly removed if needed. The connection may not be completely watertight; if a watertight connection is required, a hose clamp can be added. A Blu-Lock fitting, a special type of irrigation fitting, can be used as an alternative to barbed fittings. Blu-Lock fittings make a watertight seal and are easy to work with.

Branched-drain system A simple graywater system that uses standard drainage plumbing parts to distribute graywater by gravity out to the landscape.

Double ell (also called twin 90, double ¼ bend) A plumbing fitting that divides the flow in a branched-drain system. Typical sizes are 1½ and 2 inches.

Drainage test A test to determine how well water drains on a site.

Drip line The outer point of the leaves on a tree or shrub, where water would drip off onto the ground in a light rain. Trees should be irrigated at or beyond their drip lines; roots typically extend at least twice the distance from the trunk to the drip line.

Dual drainage plumbing Separate plumbing systems for separate wastewater flows. As applied to graywater systems, dual drainage plumbing separates graywater flows (laundries, sinks, and shower/baths) from toilet and kitchen sink wastewater, enabling the entire graywater flow to be accessed in one pipe.

Effluent pump A pump designed to pump wastewater, including graywater. A graywater effluent pump should be able to pass ¾-inch solids.

Emitter An outlet that discharges water into the landscape. Drip irrigation emitters have very small openings and thus must have adequate filtration if graywater is used. Larger emitters can be used with unfiltered graywater.

Evapotranspiration The combination of water transpired from plants and evaporated from soil and plant surfaces. The evapotranspiration rate, or ET, is one variable that determines how much irrigation plants require.

FHT (female hose thread) An adapter or fitting that has hose threads on the inside of the fitting. These hose threads are incompatible with pipe threads.

FPT (female pipe thread) An adapter or fitting that has standard pipe threads on the inside of the fitting.

Filter A device that captures lint, hair, and other particles in graywater to prevent clogging in the rest of the system.

Head height The elevation a pump is rated to pump water.

HDPE/PE High density polyethylene or polyethylene, a type of plastic that is used in irrigation tubing. The manufacturing process for HDPE and PE produces fewer toxins than that for PVC, and they are also recyclable.

Loam Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

MPT (male pipe thread) Pipes that have standard threads on the outside of the adapter or fitting.

Mulch Any material that covers the surface of the soil. For graywater systems, the preferred mulch is large wood chips (not shredded wood or small chips), as the large chips take longer to decompose and thus require less frequent replacement.

Mulch basin An area created by removing soil and filling the empty space with mulch. Mulch basins are typically located in the drip line of a plant and are sized according to the amount of graywater entering them. Mulch basins create a large space for graywater to spread out and sink into the ground without pooling or runoff.

Mulch shield See valve box.

Overflow A pipe exiting a surge tank to allow graywater to flow to the sewer in case of pump failure. The diameter of the overflow pipe must be at least the size of the total of all inlet pipes to the tank.

P-trap A curved, U-section of drain pipe that holds a water seal to prevent sewer gasses from entering a building through a fixture's drain pipe.

Pathogens of concern Disease agents and viruses that enter graywater through contact with fecal matter or other infectious agents. Such pathogens could harm health if ingested.

Phytophthora (crown rot) A plant disease caused by water pooling at the base of the plant, or crown. Crown rot can be prevented by irrigating in the drip zone of the plant and locating the plant on a mound so its crown is above the elevation of the landscape.

Plot plan A simple aerial view drawing of the site, including the footprint of the house, property lines, municipal supply lines, graywater lines, and areas to be irrigated.

Pooling Pools or puddles of water at the surface. Pooling of graywater is not allowed under the California Plumbing Code and is also unsightly. Pooled graywater provides a place for mosquitoes to breed and the potential for contact by people or pets.

PVC Polyvinyl chloride, a material commonly used for pipes. The manufacturing process is highly toxic, so PVC pipe use should be minimized. PVC is the material used to make rigid 1-inch pipe that is easy to work with.

Reclaimed water See recycled water.

Recycled water Treated wastewater produced by a wastewater treatment plant. Recycled water was not available in San Francisco at the time of writing.

Sand filter (or rapid sand filter)

Sand filters remove particles from graywater so the water can be used in a drip irrigation system. These filters do not remove salts or chemicals. To function properly, sand filters must be automatically backflushed with fresh water to clean them out. Sand filters are commonly used in pool and spa systems.

Slip connection A connection of plastic fittings made by slipping one piece of pipe inside the fitting. These fittings must be glued with the appropriate glue (depending on pipe material) to create a watertight seal.

Surge tank A tank that temporarily collects graywater before it is pumped or drained out to the landscape. Surge tanks should not store graywater for longer than 24 hours.

Surfactants (anionic and nonionic)

Substances used in detergents and cleaning products to loosen dirt from fabric and prevent it from re-adhering. Surfactants can be made from plants or petro-chemicals.

Swing-check valve (one-way valve)

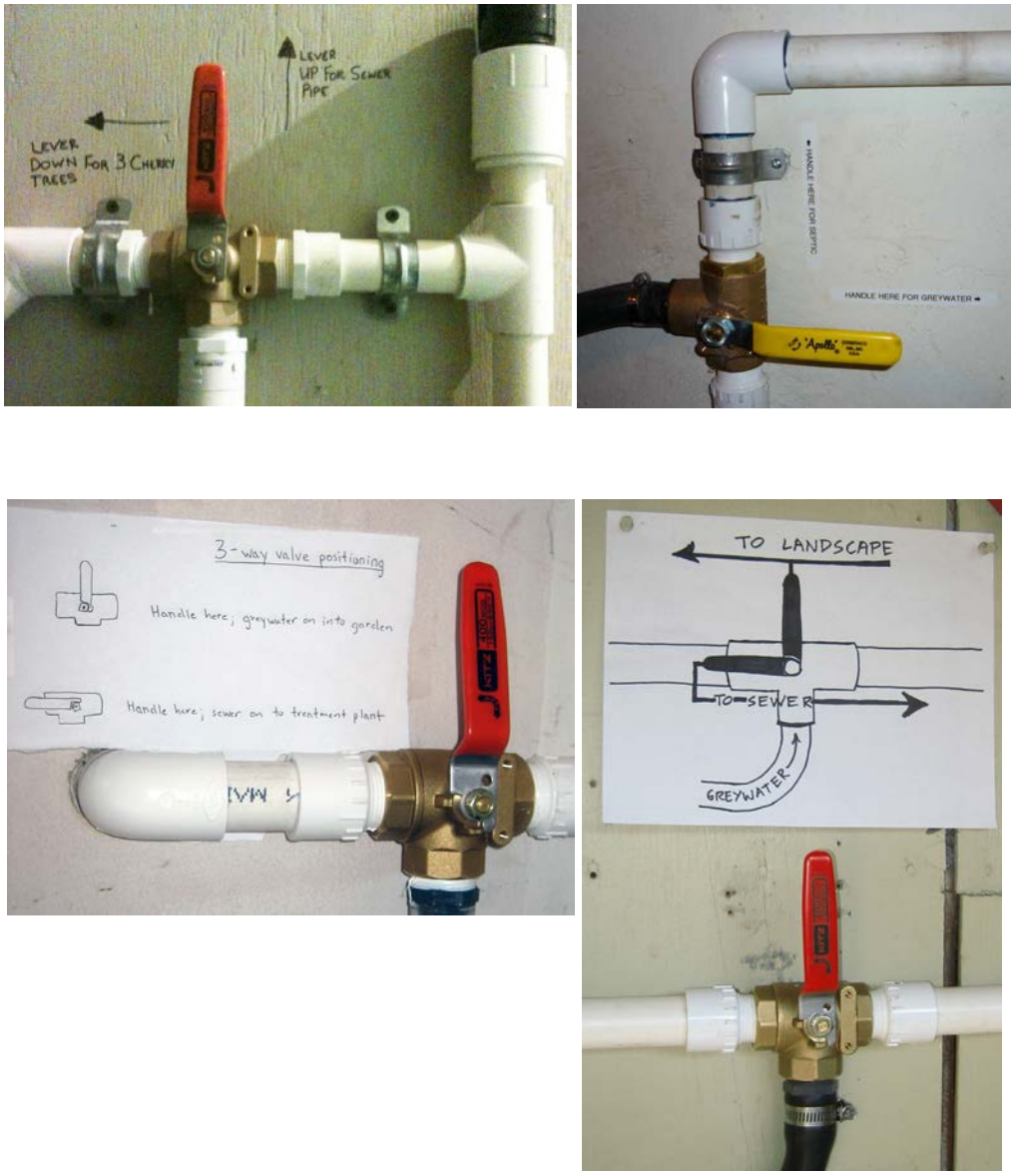
A valve that allows water to flow in one direction only. Inside the valve is a flap that swings open in one direction; if water begins to flow backward, the valve closes and prevents water from passing. These valves are used in a pumped system if the pump sends water above the elevation of the machine. Note: do not confuse a “swing” check valve with a “spring” check valve, as they are not the same thing.

Valve box Also called a mulch shield, a valve box is a subsurface cavity into which graywater is discharged. The graywater flows from the valve box into the mulch. The air space between the outlet and the mulch prevents roots from growing back into the graywater pipe and clogging the system. Valve boxes can be purchased or made at home out of 1- to 5-gallon plastic pots, the size depending on the quantity of graywater to be discharged.

Water table The upper surface of the saturated zone, where water fills the pore spaces of soil or rock.

Appendix A: Signs for Your Graywater System

- Your graywater system must be labeled so that all users (current and future) know how to turn it on and off. Sample signs are shown in the images to the right.
- You must label all above-ground graywater pipes as follows: "Caution: Non-potable water, do not drink" at intervals of 5 feet or less.
- You might also consider putting a reminder of what soaps to use on or near your machine, particularly if you share it with other people.



Examples of labeling the 3-way valve.

Appendix B: Operation and Maintenance Manual Templates

See *http://www.sfwater.org/landscape* for links to Microsoft Word versions of these templates.

Sample Operation and Maintenance Manual for Laundry-to-Landscape Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater irrigation system. This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components is attached to this manual.

Insert the calculations you used to design your system here:

My washing machine uses _____ gallons per load.

My household does _____ loads of laundry per day.

My household does _____ loads of laundry per week.

This system was designed to accommodate _____ gallons per day.

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system:

- During the rainy season.
- When washing dirty diapers.
- When washing anything with chemicals, such as oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff in the landscape.
- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (like bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic system (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*.

3. How do I maintain my graywater system?

The main thing you'll need to do to maintain your graywater system is periodically check on the mulch basins (the mulch layer the graywater flows into) and make sure the graywater is draining properly. If you notice any pooling or runoff, dig out the mulch basin and put in new mulch (wood chips or bark). Mulch usually needs to be replaced every one or two years.

At the beginning of the irrigation season, check to ensure that graywater is flowing out of the outlets evenly. If you notice uneven distribution, check the outlets for clogs, and manually remove any debris. If you notice that many of the outlets are clogged, you need to flush the system.

To flush the system, open any partially closed ball valves, making sure the end of each line is open. Pull the tubing off the PVC connection point and insert the barbed 1-inch female hose thread adapter. Attach a garden hose to the hose connection and turn the hose on high to flush particles out of the system. ***Any time you attach a garden hose to temporarily flush the system, make sure you have an anti-siphon valve or vacuum breaker on the hose bibb!*** When you are finished, be sure to readjust the ball valves for an even flow of graywater.

A basic operation and maintenance checklist for laundry-to-landscape systems is provided in Table B-1.

4. What are the 12 guidelines I must follow to comply with the law?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), washing machine systems in one- or two-unit residential buildings do not require a permit as long as the installer follows the 12 minimum requirements outlined in the code:

1. If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a graywater irrigation or disposal system. *Note: A city, county, or other local government may, after a public hearing and enactment of an ordinance or resolution, further restrict or prohibit the use of graywater systems.*

2. The design shall allow the user to direct the flow to the irrigation or disposal field or the building sewer. The direction control of the graywater shall be clearly labeled and readily accessible to the user.

Table B-1. *Laundry-to-Landscape System: Operation and Maintenance Checklist*

Component	Inspection Schedule	O&M Activity	Action Needed
3-way valve	Annual	Check for leaks at washer hose and that label is in place	☐ Condition good ☐ Action needed • If leaking, tighten hose clamp. • Replace label if needed.
Auto vent	Annual	Check for leaks from auto vent	☐ Condition good ☐ Action needed If leaking, replace the auto vent.
Piping and tubing	If you notice water in an unusual place	Check for leaks	☐ Condition good ☐ Action needed If piping or tubing is damaged, cut out damaged section and reconnect with a 1-inch barbed coupling.
	Annual	Check for even distribution from outlets	☐ Condition good ☐ Action needed Unclog hair or lint built up in the outlets. Open ball valves, check for clogs. If needed, flush the system with a hose: temporarily disconnect the tubing from the PVC fitting, attach the garden hose by barb fitting, and connect the hose to the system.
Mulch basins	Annual	Check to see if mulch has decomposed and water is pooling under graywater outlets	☐ Condition good ☐ Action needed Remove decomposed mulch and add new mulch.

3. The installation, change, alteration or repair of the system does not include a potable water connection or a pump and does not affect other building, plumbing, electrical or mechanical components including structural features, egress, fire-life safety, sanitation, potable water supply piping or accessibility.

4. The graywater shall be contained on the site where it is generated.

5. Graywater shall be directed to and contained within an irrigation or disposal field.

6. Ponding or runoff is prohibited and shall be considered a nuisance.

7. Graywater may be released above the ground surface provided at least two (2) inches (51 mm) of mulch, rock, or soil, or a solid shield covers the release point. Other methods which provide equivalent separation are also acceptable.

8. Graywater systems shall be designed to minimize contact with humans and domestic pets.

9. Water used to wash diapers or similarly soiled or infectious garments shall not be used and shall be diverted to the building sewer.

10. Graywater shall not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.

11. Exemption from construction permit requirements of this code shall not be deemed to grant authorization for any graywater system to be installed in a manner that violates other provisions of this code or any other laws or ordinances of the Enforcing Agency.

12. An operation and maintenance manual shall be provided. Directions shall indicate the manual is to remain with the building throughout the life of the system and indicate that upon change of ownership or occupancy, the new owner or tenant shall be notified the structure contains a graywater system.

Sample Operation and Maintenance Manual for Branched-Drain Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater irrigation system.

This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components is attached to this O&M manual.

Insert the information you used to design your system here:

Estimated graywater flow (permitted systems calculation) _____

Soil type _____

Minimum size of irrigation or infiltration area required _____

Actual size of irrigation or infiltration area _____

Estimated graywater flow (irrigation calculations) _____

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system.

- During the rainy season.
- When washing dirty diapers.
- When washing anything with chemicals, such as oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff

in the landscape.

- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (like bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also find out what's in your products at *http://cosmeticdatabase.org*. In a shower, shampoo is fairly diluted so it is not as important as detergents in the washing machine.

3. How do I maintain my graywater system?

The main thing you'll need to do to maintain your graywater system is periodically check on the mulch basins (the mulch layer the graywater flows into) and make sure the graywater is draining properly. If you notice any pooling or runoff, dig out the mulch basin and put in new mulch (wood chips or bark). Mulch usually needs to be replaced every one or two years.

At the beginning of the irrigation season, check to ensure that graywater is flowing out of the outlets evenly. If you notice uneven distribution of graywater, check the outlets for clogs, and manually remove any debris you find. If you notice that many of the outlets are clogged, you need to flush the system. There could be some settling of the system over time, which could result in uneven distribution out of the outlets. You can readjust the slope of the double-ell (twin 90) flow splitters to even out the flow.

To "flush" the system, insert a garden hose into a cleanout and force water through the system. If there is a blockage, you can insert a "snake" to push out a clog.

4. What is required to keep my system legal and in compliance with the graywater code?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), the requirements below must be followed:

- The graywater system shall not be connected to any potable water system without an air gap or other physical device which prevents backflow and shall not cause the ponding or runoff of graywater.
- No graywater system or part thereof shall be located on any lot other than the lot that is the site of the building or structure that discharges the graywater, nor shall any graywater system or part thereof be located at any point having less than the minimum distances indicated in Table 16A-1.
- Water used to wash diapers or similarly soiled or infectious garments or other prohibited contents shall be diverted by the user to the building sewer.

- Graywater shall not be used in spray irrigation, allowed to pond or runoff and shall not be discharged directly into or reach any storm sewer system or any surface body of water.
- Human contact with graywater or the soil irrigated by graywater shall be minimized and avoided, except as required to maintain the graywater system. The discharge point of any graywater irrigation or disposal field shall be covered by at least (2) inches of mulch, rock, or soil, or a solid shield to minimize the possibility of human contact.
- Graywater shall not be used to irrigate root crops or edible parts of food crops that touch the soil.

Sample Operation and Maintenance Manual for Pumped Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater system.

This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components is attached to this O&M manual.

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off when you want and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system:

- During the rainy season.
- When washing dirty diapers.
- When washing anything with chemicals, like oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff in the landscape.
- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (such as bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic system (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also find out what's in your products at *http://cosmeticdatabase.org*. In a shower, shampoo is fairly diluted so it is not as important as detergents in the washing machine.

3. How do I maintain my system?

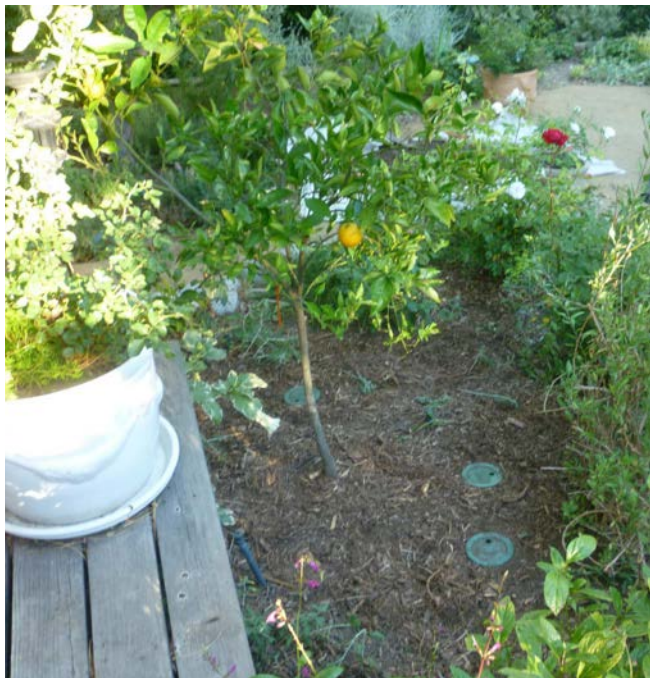
The pump in your system should last for many years, but it will eventually need to be replaced. If you hear the pump running more frequently than normal, or you don't hear it at all, check the system to make sure it's working. Common problems include the float switch catching on something or the pump breaking, causing graywater to drain through the overflow to the sewer/septic system.

In the landscape, if you notice any pooling or runoff, dig out the mulch area and replenish it with new mulch (wood chips or bark). Mulch usually needs to be replaced every one or two years.

4. What is required to keep my system legal and in compliance with the graywater code?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), the requirements below must be followed:

- The graywater system shall not be connected to any potable water system without an air gap or other physical device which prevents backflow and shall not cause the ponding or runoff of graywater.
- No graywater system or part thereof shall be located on any lot other than the lot that is the site of the building or structure that discharges the graywater, nor shall any graywater system or part thereof be located at any point having less than the minimum distances indicated in Table 16A-1.
- Water used to wash diapers or similarly soiled or infectious garments or other prohibited contents shall be diverted by the user to the building sewer.
- Graywater shall not be used in spray irrigation, allowed to pond or runoff and shall not be discharged directly into or reach any storm sewer system or any surface body of water.
- Human contact with graywater or the soil irrigated by graywater shall be minimized and avoided, except as required to maintain the graywater system. The discharge point of any graywater irrigation or disposal field shall be covered by at least (2) inches of mulch, rock, or soil, or a solid shield to minimize the possibility of human contact.
- Graywater shall not be used to irrigate root crops or edible parts of food crops that touch the soil.



This graywater system is used to irrigate plants with similar water needs. The fruit trees and larger perennials are irrigated from the laundry machine in one "hydrozone." Photo: Leigh Jerrard.

Appendix C: Products

Product Ingredients to Avoid

***Salt and sodium compounds*:** Salts can build up in the soil and prevent plants from taking up nutrients. Over time, salt build-up can kill plants.

***Boron or borax*:** Boron is a plant micronutrient, but once plants have their boron needs met, it quickly becomes a microtoxin that damages plants. Since boron is non-toxic to people, it is a common element in ecological detergents. To avoid boron poisoning of your plants, do not use any soap or detergent that contains boron or borax.

***Chlorine bleach*:** Chlorine bleach kills soil microorganisms and can damage your plants. Do not use it in a graywater system! Hydrogen peroxide bleach can be used as an alternative.

Recommended Soaps and Products

Look for products that are free of the ingredients above. For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and http://*www.harvesingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also read the back of detergent bottles. If a company doesn't list all its ingredients, you'll have no way of knowing if the product is safe for your plants or not. There are also soap alternatives for laundry machines, such as soap nuts, magnets, and balls that deionize the water.

Cleaners: Many cleaners have high levels of salts, contain harmful chemicals, and can be very basic (alkaline). In general, cleaning products made from vinegar are better for plants. Use cleaners sparingly.

Personal care products: If you are interested in learning more about the ingredients in your shampoos, conditioners, and deodorants, visit *http://cosmeticdatabase.org*, an on-line information site that allows you to investigate what is in your products.

Appendix D: What to Irrigate with Graywater and How Much Water to Use

Irrigation

The key to proper irrigation with low-tech graywater systems is to get an accurate estimate of how much graywater is produced and then match the available amount of graywater with the proper plants. Typically, plants with larger root zones, like trees and shrubs, can withstand times without irrigation, although they do better with regular watering.

"Hydrozoning" is keeping plants with similar water needs on the same irrigation cycle. This practice is important for conserving water in a landscape. In a landscape irrigated with graywater, it is important to put your water-loving plants in locations accessible to graywater while putting drought-tolerant plants in other areas. This way you can avoid the need for irrigation with potable water. Low-tech graywater systems typically supply only one hydrozone at a time, whereas more complex systems can supply multiple hydrozones.

The information below will help you estimate how much of your landscape can be irrigated using a graywater system.

A typical medium-sized fruit tree in San Francisco needs approximately 10 to 20 gallons of water per week during the dry season. Using this rough estimate, graywater from one load of laundry from a front-loading machine (approximately 20 gallons) could irrigate one to two trees per week; graywater from a top loader could irrigate three to four trees per week (approximately 40 gallons).

Another easy rule of thumb for estimating plant water needs is to find the square footage of the plant's canopy and divide it by 4. This approximates the gallons per week the plant needs. For example, an apple tree with a canopy area of 80 square feet might need 80/4, or about 20 gallons per week. Note that drought-tolerant plants require much less water than estimated by this method!

You can also use an equation to estimate how much water your specific plants need. However, note that there are many variables that affect plant water needs, so any technique

***Table D-1**. Water Needs of Some Common Plants.*

Low (Species Factor 0.2)	*Moderate (Species Factor 0.5)*	*High (Species Factor 0.8)*
California poppy	*Tulip tree*	*Birch*
Pineapple guava	*Apple tree*	*Willow*
European grape	*Fig tree*	*Coast redwood*
Bougainvillea	*(Most other fruit trees)*	*Kiwi*
Lemon verbena	*Shasta daisy*	*White Alder*

Source: Water Use Classification of Landscape Species, California Department of Water Resources.

Source: California Irrigation Management Information System (CIMIS)

REFERENCE EVAPOTRANSPIRATION

Legend

1 COASTAL PLAINS HEAVY FOG BELT
Lowest ETo in California, characterized by dense fog

2 COASTAL MIXED FOG AREA
Less fog and higher ETo than zone 1

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0

Figure D-1. *Reference evapotranspiration zones in San Francisco.*

you use will be an approximation. The most important thing is to observe your plants and note how they are doing.

The equation for plant water requirements on the following page provides a method for calculating how many gallons per week a specific plant or planted area requires. To use this equation, you need the following information:

- **The area of the plants:** Estimate the planted area using the area of a circle for trees (the distance from the trunk to the drip line is the radius of the circle) or the area of a rectangle for rectangular-shaped planted areas.
- **The species factor of the plant(s):** Available at *http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf* or in the *Sunset Western Garden Book*. The species factor is a number used to differentiate between the water needs of plants (high, moderate, and low). Table D-1 lists the species factors of some common plants in San Francisco.
- **The evapotranspiration, or ET, rate:** Available at *http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp#.* Evapotranspiration is a combination of water transpired from plants and evaporated from soil and plant surfaces. Evapotranspiration is given in inches per month or inches per day. You can convert this to inches per week. Figure D-1 includes a map of ET zones in San Francisco and ET rates for each month of the year.

Plant water requirements (in gallons per week) = 0.62 (conversion factor for the ET rate, converting inches to gallons) x planted area (square feet) x species factor (high, moderate, or low) x evapotranspiration (ET) rate (inches per week).

For simplicity, it is assumed that all the water goes to the roots of the plants, i.e., that the irrigation is 100 percent efficient.

Note that although July has the highest ET and thus the highest irrigation needs of the year, you don't need to irrigate at the July rate all year long. You could decide to irrigate your plants with graywater at less than their July requirement for most of the year, knowing that your plants might need additional water in July. Alternatively, if you have more graywater than your plants need, you could irrigate your plants according to their peak need all year round, even though they don't need that much water most of the year. If your drainage is good, slight over-watering with graywater will not harm your plants, although it is unnecessary.

To learn more about plant water requirements and evapotranspiration rates, visit the California Irrigation Management Information Systems (CIMIS) at *http://wwwcimis.water.ca.gov/*.

Example: Estimating How Much Water Your Plants Need

A western San Francisco household has a yard with eight small fruit trees and native plants. The homeowners currently irrigate the trees using tap water, but they would like to use graywater from their washing machine instead. The homeowners estimate that they produce 60 gallons of graywater from their washing machine per week. The drip lines of the trees are 3 feet from their trunks.

The homeowners start by making a rough estimate of how much water the trees need. Since a medium-sized fruit tree requires between 10 and 20 gallons per week, they assume that their small fruit trees will need less than 10 gallons per week, or less than a total of 80 gallons for all eight trees.

For a more accurate estimate, they use the plant water requirements formula on the top of D-3.

Three variables are needed for this calculation: area of the trees, species factor, and evapotranspiration (ET) rate.

Area of each tree: πr^2 = 3 x 3 feet x 3 feet = 27 square feet (note that π = 3.14, but 3 is close enough for this estimate)

Species factor: 0.5 (from *http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf* or the *Sunset Western Garden Book*)

July weekly ET = 1.16 and April weekly ET = 0.82

Using the plant water requirements formula:

Weekly plant water needs in July (in gallons) = 0.62 x 1.16 (July ET weekly) x 0.5 (species factor) x 27 square feet (area of each tree) = 9.7 gallons per week in July

Using the April ET weekly rate of 0.82, the homeowners calculate that each tree requires 6.9 gallons per week in April.

The homeowners estimate that if they split the 60 gallons equally between eight trees, each will get approximately 7 gallons a week. This is less than the peak irrigation need in July but enough for most of the year. They decide to install a laundry-to-landscape system, with graywater distributed equally to all eight trees. They plan to observe the trees in the summer. If the trees exhibit signs of water stress, they will supplement the graywater irrigation with tap water.

Graywater irrigates this row of fruit trees. Thick mulch from a local tree company has been placed over the pathway, as well as inside the mulch basins. Photo: Leigh Jerrard.

Edibles

You can safely irrigate edible crops with graywater, as long as the graywater does not touch the edible part of the plant. For example, the California graywater code prohibits watering root crops like carrots with graywater. It is possible that the graywater could contact the carrots, and someone who ate a carrot without washing it first could ingest graywater. It is generally easier to irrigate perennial plants and trees with graywater; good edibles to water can be fruit trees, fruiting vines, berries, and large perennials.

Any system that uses drip irrigation tubing can water all types of vegetables with the edible portion above the ground. Vegetable beds with larger annuals and food above the ground, like corn, beans, tomatoes, etc. can be watered with laundry and pumped systems, since it is easier to spread out the water to reach these types of plants with these pumped systems. In contrast, it is not as easy to irrigate vegetables with gravity-fed, branched-drain systems.

Easy Plants to Water

- Fruit trees adapted to your local microclimate
- Berries
- Riparian plants that like irrigation (willow, maple, birch, water-loving plants)
- Any plant that likes to be irrigated

What Not to Water

- Root crops. Reason: Health risk. Someone ingesting a root crop without washing it could ingest graywater. The graywater code prohibits irrigation of root crops.
- Drought-established plants. Reason: Risk to plant. Plants that have never been watered before, like an oak tree, or an old citrus that was never irrigated, are used to extended dry periods and could be damaged by sudden frequent irrigation.
- Possibly acid-loving plants (depending on the pH of graywater). Reason: Risk to plant. Graywater tends to be basic (alkaline), and acid-loving plants might not do well with basic irrigation water. You can use pH-neutral liquid laundry detergents

and put acidic bark in mulch basins to create acidic soil conditions. Common acid-loving plants include ferns, azaleas, rhododendrons, camellias, and blueberries. You can look up the pH needs of your plants in a plant or gardening book. If the book doesn't mention pH or acidic conditions, it is generally safe to assume the plant doesn't need acidic conditions, as garden plants commonly prefer neutral or slightly alkaline conditions.

- Very sensitive plants. Reason: Risk to plant. Plants that are generally hard to grow, like some ferns and avocados, might not be a good choice for graywater irrigation.

Soil Health

To have healthy plants, you need healthy soils! Soils are alive with billions of beneficial organisms. These are some easy steps you can take to promote healthy soils in your yard:

- A few times a year, irrigate with rainwater or freshwater. A rainy day counts!
- Add compost to your soil.
- Use mulch.
- Don't use chemical pesticides or fertilizers.

References

California Irrigation Management Information Systems (CIMIS) at: http://wwwcimis.water.ca.gov/f

Sunset Western Garden Book 8th Edition, 2007

California Department of Water Resources Water Use Classification of Landscape Species at: http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf

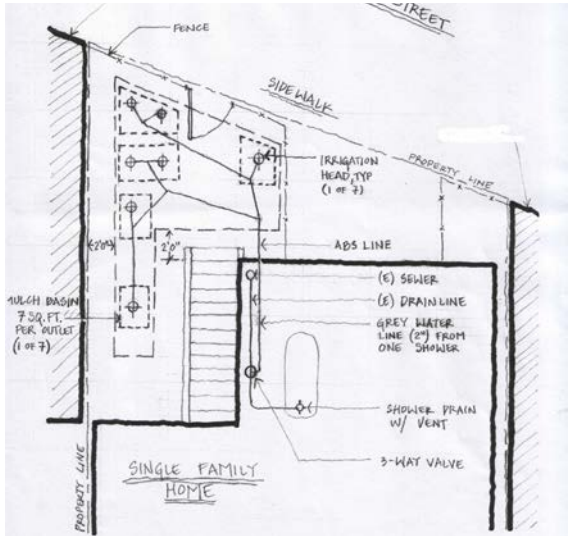
SFPUC Low Water Use and Climate Appropriate Plant List at: sfwater.org/landscape

DATE OF REPORT: 08/13/10

SOIL PHYSICAL CHARACTERISTICS

Sample ID	Lab Number	% Sand	% Silt	% Clay	Soil Texture
FRYRD	55218	66	20	13	SANDY LOAM

Sample laboratory results from a soil texture analysis.



Sample plot plan showing the street, building, setbacks, location of irrigation area, and size of mulch basins.

Appendix E: Worked Example with Sample Plot Plans and Permits

The following is a simplified example of the design and permitting steps followed by one set of San Francisco homeowners when they installed a branched-drain graywater system. This section describes an overview of the steps they followed and includes samples of the documentation they submitted with their permit application. Note that elements of this worked example have been fictionalized for simplicity and clarity.

Note that if you are installing your own system, you will need to consult the applicable sections of this manual for an overview on installing your system as well as consult additional resources for further guidance on branched-drain system installation details.

Step 1: Estimated the gallons of graywater generated by the shower fixture in a one bedroom home using the permitted systems estimation method on page 9 of this manual.

- One-bedroom home = 2 occupants
- System uses graywater from a shower only: 25gpd x 2 people = 50 gpd

Step 2: Identified the soil type.

- Soil ribbon test indicated soil to be sandy loam. Soil was also sent to a laboratory for soil texture analysis, which confirmed the soil to be sandy loam.

Step 3: Calculated minimum irrigation, or infiltration, area based on soil type and gallons of graywater generated per day. This process is described on page 14 of this manual.

- As shown in Table 2 of this manual, "sandy loam soil" needs 0.4 square feet of infiltration area per gallon per day.
- 0.4 square feet per gallon per day x 50 gpd = 20 square feet

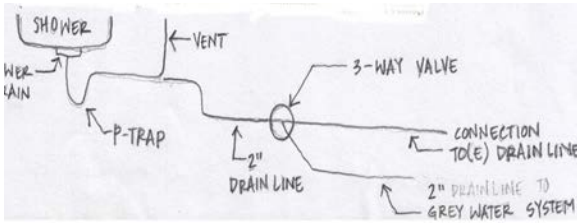
Step 4: Drew a plot plan and plumbing detail (see plot plan at left).

- In the plot plan, the flow was divided into seven outlets, with basins of 7 square feet each, totaling 49 square feet of infiltration area. This number is significantly higher than the minimum 20 square feet calculated using Table 2 of this manual, as the homeowners designed their system to spread the graywater out to many plants across their yard.
- The plumbing diagram on the right shows the 3-way valve located after the p-trap and vent, as well as the size of pipe used. The graywater pipe is 2-inch ABS (plastic), since it is for irrigation, while the rest of the plumbing is of cast iron.
- Note that this house had up-to-code plumbing, but if it didn't, the homeowners would have needed to upgrade the plumbing affected by the installation of the graywater system. For example, if the shower drain had been undersized, it would have needed to be upgraded to 2-inch pipe.
- Exterior walls within 5 feet of the property line must be fire-rated. If your pipe exits a fire-rated wall, then you must comply with applicable building and plumbing codes to ensure that the integrity of the wall is not compromised. Consult a professional or contact DBI with questions.

Step 5: Applied for a permit.

Step 6: Constructed the system.

- Installed the system. Note that although outdoor piping for a branched-drain system must be buried, it does not have to meet burial depth standards for sewer pipes. This system started with the pipe shallowly buried (approximately 2 inches) and got deeper as the system progressed.
- Tested system.
- Buried straight runs of pipe. Runs with bends were left exposed for inspection.



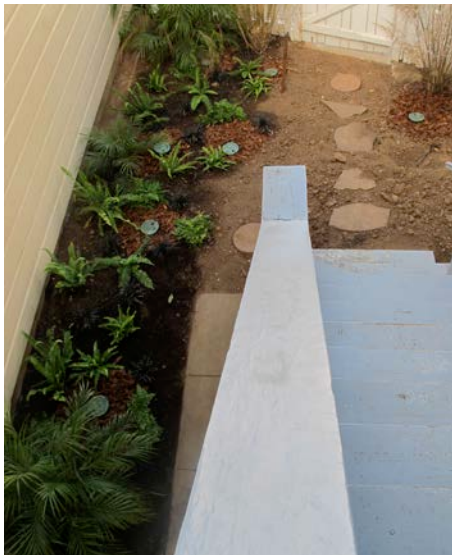
Sample plumbing detail showing the 3-way valve connection after the p-trap and vent; pipe size shown as 2-inch, which is required for a shower drain.


PLUMBING PERMIT
CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF BUILDING INSPECTION

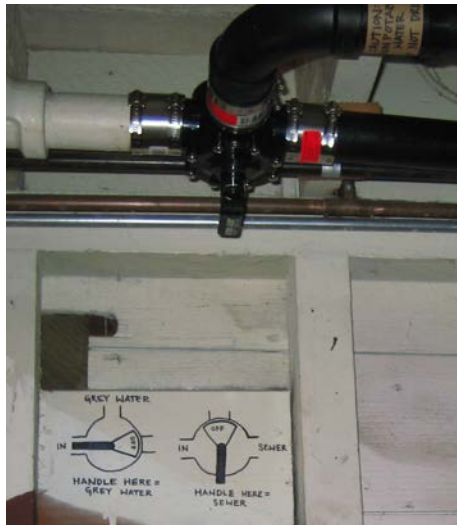
PERMIT #

Sample graywater permit.

Sample image of a graywater system pre-burial. Photo: Josh Lowe.



Sample image of a completed graywater system. Photo: Josh Lowe.



Sample image of a 3-way valve clearly labeled. Photo: Josh Lowe.

- Labeled above-ground pipe.
- Labeled 3-way valve.
- Attached O&M manual under the 3-way valve.

Step 7: Called DBI to schedule an inspection.

Appendix F: Information and Resources

On-line Information

San Francisco Public Utilities Commission: *http://sfwater.org/landscape*

San Francisco Department of Building Inspection: *http://www.sfdbi.org*

San Francisco Department of Public Health: *http://www.sfdph.org/*

California Graywater Code*:*
http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf

Additional Resources

Note that the following lists are not comprehensive and contain only a few of the resources available to homeowners designing and installing graywater systems. The inclusion of these organizations and resources is intended to assist homeowners and designers in their process and does not imply any endorsement by the SFPUC.

Oasis Design Graywater Information Site: *http://www.oasisdesign.net/greywater*

Greywater Action: For a Sustainable Water Culture: *http://www.greywateraction.org*

California's Integrated Water Efficiency and Reuse Information and Certification Center: *http://www.whollyh2o.org/*

Books

Create an Oasis with Greywater, by Art Ludwig. 19th Revision, Oasis Design. 2009.

Golden Gate Gardening: Year-Round Food Gardening in the San Francisco Bay Area and Coastal California, by Pam Pierce. 1998.

Classes

Greywater Action: *http://www.greywateraction.org/*

The Ecology Center: *http://www.ecologycenter.org/*

The Garden for the Environment: *http://www.gardenfortheenvironment.org/*

Plants

California Irrigation Management Information System: *http://wwwcimis.water.ca.gov*

Laboratories for Soil Analyses

A&L Western Agricultural Laboratories. (209) 529-4080. Modesto, California

Materials

Urban Farmer Store (kits for laundry to landscape systems): *http://urbanfarmerstore.com/*

Clean Water Components (kits for graywater systems): *http://cleanwatercomponents.com*

Bayview Greenwaste (for mulch): *http://bayviewgreenwaste.com/*

Local tree trimmers (for wood chips)

SAN FRANCISCO

graywater design manual

FOR OUTDOOR IRRIGATION

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WATER
WASTEWATER
POWER