

## Use of Graywater in Urban Landscapes in California

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### Definition and Overview

The use of graywater (also spelled greywater, grey water and gray water) to irrigate landscape plants is increasing throughout the United States, particularly in California and other arid states. Municipalities are rapidly amending their codes to encourage the use of home graywater systems. This publication describes what graywater is, basics of laundry to landscape systems, and associated benefits and risks of graywater systems to humans and other animals as well as to plants.

In California, under Health and Safety Code § 17922.12, graywater is defined as “untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. Graywater includes, but is not limited to, wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers.”

A construction permit is no longer required for the installation of a single-family or two-family residential graywater irrigation system from a washing machine to an outdoor irrigation or disposal field as long as it does not alter the household plumbing (graywater is accessed from the hose of the washing machine, not by cutting into plumbing), and complies with the following:

- 1. If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a graywater irrigation or disposal system.*
- 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.*
- 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. (Note: The pump in a clothes washer shall not be considered part of the graywater system.)*
- 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.”*

All other graywater systems aside from ‘laundry to landscape’ types described above require a construction permit prior to erection, retrofitting, construction and installation as stated in the California plumbing code. Examples include:

- Simple System. A graywater system serving a one- or two-family dwelling with a discharge of 250 gallons (947 L) per day or less.
- Complex System. A graywater system that discharges over 250 gallons (947L) per day.

The updated code and its provisions for use of graywater to irrigate landscapes can be found in its entirety here: [http://www.hcd.ca.gov/codes/shl/2007CPC\\_Graywater\\_Complete\\_2-2-10.pdf](http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf)

**Important definitions included in the California graywater code:**

**Irrigation field**: an intended destination for graywater in the receiving landscape including but not limited to a drip irrigation system, mulch basin, or other approved method of dispersal for irrigation purposes.

**Disposal field**: an intended destination for graywater including but not limited to a mulch basin or receiving landscape feature, graywater leach field, or other approved method of disposal.

**Mulch basin**: a type of irrigation or disposal field filled with mulch or other approved permeable material of sufficient depth, length and width to prevent ponding or runoff. A mulch basin may include a basin around a tree, a trough along a row of plants or other shapes necessary for irrigation or disposal.

It is important to note that cities, counties, and other local jurisdictions can impose stricter guidelines than the state; homeowners interested in installing graywater systems should contact their local jurisdiction for specific regulations concerning graywater handling and use.

## The Basics of 'Laundry to Landscape' Graywater Systems

Laundry-to-landscape graywater systems are relatively simple to install and inexpensive. The number of cities and counties approving the use of these graywater systems without requiring permits is rapidly increasing. Metropolitan areas including Berkeley, Los Angeles, San Francisco, Santa Barbara, San Diego, and Santa Rosa no longer require permits for these systems. Some even offer rebates to install graywater systems and many offer regular workshops on system design and installation. Specific details regarding system requirements, rebates, and workshops can be found below:

Berkeley: [http://www.ci.berkeley.ca.us/Planning\\_and\\_Development/Energy\\_and\\_Sustainable\\_Development/Graywater\\_Clothes\\_Washer\\_System\\_Laundry\\_to\\_Landscape.aspx](http://www.ci.berkeley.ca.us/Planning_and_Development/Energy_and_Sustainable_Development/Graywater_Clothes_Washer_System_Laundry_to_Landscape.aspx)

Los Angeles: [http://ladbs.org/LADBSWeb/LADBS\\_Forms/InformationBulletins/IB-P-PC2014-012Graywater.pdf](http://ladbs.org/LADBSWeb/LADBS_Forms/InformationBulletins/IB-P-PC2014-012Graywater.pdf).

San Francisco: <http://sfwater.org/modules/showdocument.aspx?documentid=55>

Santa Barbara County: <http://www.waterwisesb.org/documents/greywater.pdf>

San Diego (City): <http://www.sandiego.gov/water/recycled/graywater.shtml>

Santa Rosa: <http://ci.santa-rosa.ca.us/departments/utilities/conserve/Pages/Graywater.aspx>

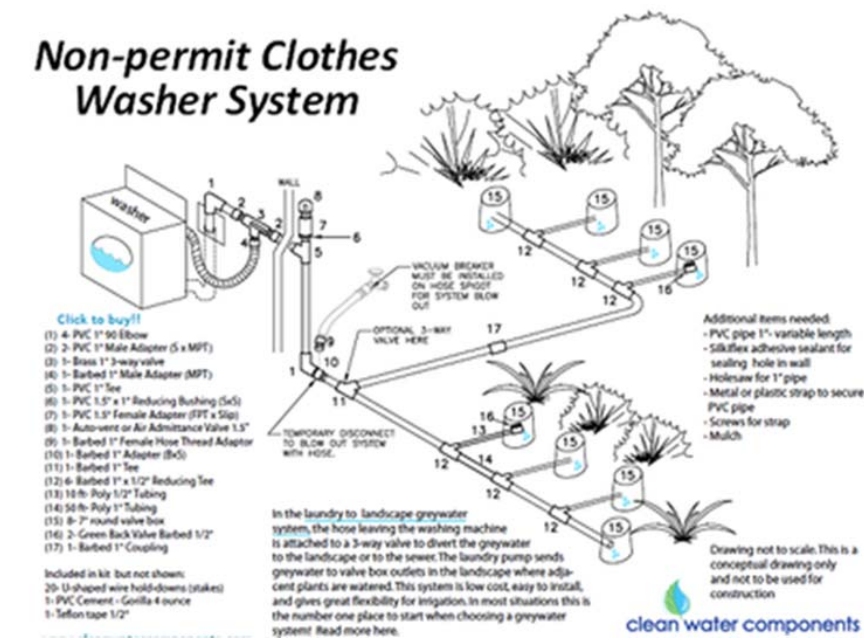


Diagram of a 'laundry to landscape' graywater system (source: Clean Water Components).

**How do ‘laundry to landscape’ graywater systems work?** The hose exiting the clothes washing machine is attached to a valve that separates graywater from water destined for the sewer. All water can be channeled directly into the sewer when bleach or powder-based detergents are used, when a graywater use quota is exceeded (a detailed explanation with examples is found on page 9 of the San Francisco design manual for outdoor use: <http://sfwater.org/modules/showdocument.aspx?documentid=55>) or when a rain event occurs raising the groundwater level. Graywater is directed to and contained within an irrigation or disposal field (refer to definitions above). A vacuum break or backflow prevention device may also be needed. When using ‘laundry to landscape systems’ it is important to select appropriate detergents and related cleaning products to reduce the chance of adverse effects on irrigated plants and the environment. Refer to ‘Impact of graywater on plant health’ below for help selecting appropriate detergents and other products that are recommended for these systems.



A ‘laundry to landscape’ graywater system 3-way valve separates water destined for the sewer from water used to irrigate landscape plants (source: <http://centralcoastgreywater.org/>).

The simplest ‘laundry to landscape’ graywater systems often discharge water directly into mulch basins via mulch shields. Leaving an air space between the pipe and the ground helps prevent plant roots from growing into and clogging the graywater pipe.



An example of a ‘mulch shield’ (source: [greywateraction.org](http://greywateraction.org)).

Mulch basins constructed by replacing several inches of soil with coarse organic mulch to irrigate flowerbeds and small ornamentals are common and are generally not problematic to plant growth. However, basins constructed within the drip line (see photo below) of mature trees are not recommended and can result in injury to established roots and unstable and unsafe trees subject to failure over time. How can this happen? Small, restrictive mulch basins may result in roots that grow in circular patterns and never grow outward beyond the mulch basin into native soil injuring tree roots and creating unstable trees subject to failure.

**Table 16A-2 Design Criteria of Six Typical Soils**

<b>Type of Soil</b>	<b>Square Feet</b>	<b>Gallons</b>	<b>Square Meters</b>	<b>Liters</b>
	<i>Minimum square feet of irrigation/leaching area per 100 gallons of estimated graywater discharge per day</i>	<i>Maximum absorption capacity in gallons per square foot of irrigation/leaching area for a 24-hour period</i>	<i>Minimum square meters of irrigation/leaching area per liter of estimated graywater discharge per day</i>	<i>Maximum absorption capacity in liters per square meter of irrigation/leaching area for a 24-hour period</i>
<i>Coarse sand or gravel</i>	20	5.0	0.005	203.7
<i>Fine sand</i>	25	4.0	0.006	162.9
<i>Sandy loam</i>	40	2.5	0.010	101.8
<i>Sandy clay</i>	60	1.7	0.015	69.2
<i>Clay with considerable sand or gravel</i>	90	1.1	0.022	44.8
<i>Clay with small amounts of sand or gravel</i>	120	0.8	0.030	32.6

Tree roots should not be cut into or severed within the dripline. Irrigation water should be applied within the dripline and not on or near the main trunk (source: Univ. of MN Coop. Extension).

If mulch basins are used, they must be sized correctly to prevent surface pooling and in accordance with Table 16A-2 in the plumbing code shown below. Remember that graywater may not be allowed to sit unused for more than 24 hours and that the discharge point (disposal field) must have a two inch or greater layer of mulch, rock, or soil or a solid shield to minimize human contact.

The sizing of the mulch basin depends mainly on soil texture (sandy loam, clay loam, etc.). Graywater percolates quickly through sandy soil, requiring minimal mulch. In slower-percolating clay loam soil, a larger mulch basin is required around the valve box to prevent graywater pooling. Large wood chip mulch is more durable and longer lasting than smaller wood chip mulches or shredded fiber and is therefore preferred. A series of holes/valves that are between 3/8 inch and one inch are added to reduce backpressure on the pump. Mature trees may require ten or more mulch basins to avoid overloading the pump and to achieve even distribution. For

instance if each basin is four inches in diameter (12.6 square feet) ten basins will irrigate 126 square feet of rooting area. Remember that mulch decomposes over time, requiring regular augmentation to maintain the required two inch depth.

## Other Graywater Systems

‘Branched drain’ types (shown below) of graywater systems rely on gravity to distribute graywater to mulch basins. While often capturing graywater from showers, they can also be used in conjunction with washing machines as ‘laundry to landscape’ systems. They only work when plantings are located below the water source since they do not contain an external pump. ‘Branched drain’ systems are excellent methods of watering trees and shrubs. The final exiting point of each branch are trees and shrubs in mulch basins. While these systems are relatively maintenance-free and efficient once installed the installation process may be difficult and homeowners may want to hire an expert to install them. Like other ‘laundry to landscape’ systems, no filters need to be changed and no additional wiring or pumps are required and cleanouts can be incorporated for regular, easy flushing.



Example of a ‘branched drain’ graywater system relying on gravity (source: [centralcoastgreywater.org](http://centralcoastgreywater.org)).

**Laundry drum graywater systems** pump household water into a surge tank which is a large barrel or watertight storage container. Simple systems take advantage of gravity to move water downhill but are not suitable for upward elevations. The water drains out of the bottom of the drum into a hose that the homeowner can move around the yard as needed. Laundry drum systems are inexpensive and efficient methods of irrigating landscape plants. They are well suited to residential landscapes as well as small plantings maintained by apartment renters. When uphill pumping is required, drums (watertight temporary storage containers) connected to



effluent pumps that move graywater uphill are needed. (Since no filters are used in these systems, they are not compatible with drip irrigation due to clogging.)

**How much graywater can be harvested by a household washing machine?**

On average, between ten and 25 gallons of water is generated per washing machine load from a horizontal-drum machine (side loader) and about 40 gallons per washer load from a vertical drum machine that loads from the top. Since the maximum flow rate from newer high efficiency washers may be as low as 1.5 gallon per minute (far less than that of many top-loading machines) it is important to limit the number of outlets per zone. (The average amount of graywater generated by one person per day recycled via a laundry to landscape system is estimated at 15 gallons. In comparison, per capita daily graywater production from showers, bathtubs, and lavatories is estimated at 25 gallons.)

**How many trees and shrubs can be irrigated using graywater from a ‘laundry to landscape’ graywater system?**

It depends on the amount of graywater generated, the climate zone, and the water requirements of the plants. Here are some examples. Two hundred gallons of graywater generated each week can keep four 100 sq ft canopied high-water requiring mature trees well irrigated and healthy in Sacramento and Riverside/San Bernardino (inland climate zones) but is only enough to keep two high-water requiring trees healthy in hotter desert climates. Conversely, high-water requiring trees in coastal climates will perform well on much less water. Low-water requiring plants in coastal areas require the least amount of water under all circumstances.

The table below illustrates how many gallons of water per week well-established trees and shrubs of various canopy sizes require in July, the highest water-demanding month of the year. Keep in mind that under drought and water restrictions most plants can be kept alive on less than half of these rates.

**Gallons of Water Per Week Required  
(for optimal growth)**

<b>Climate</b>	<b>Relative Water Requirement of Tree/Shrub (July)</b>	<b>50 square foot canopy</b>	<b>100 square foot canopy</b>	<b>200 square foot canopy</b>
Coastal (historical evapotranspiration = 1 inch/week)	Low	10	19	38
	Medium	16	31	62
	High	25	50	100
Inland (historical evapotranspiration)	Low	19	38	76

= 2 inches/week)				
	Medium	31	62	124
	High	50	100	200
Desert (historical evapotranspiration = 3 inches/week)	Low	28	57	114
	Medium	47	93	186
	High	75	150	300

Table adapted from CA Dept. of Water Resources ‘Using greywater in your home landscape’ CA Dept. of Water Resources. 1995. [http://www.water.ca.gov/wateruseefficiency/docs/graywater\\_guide\\_book.pdf](http://www.water.ca.gov/wateruseefficiency/docs/graywater_guide_book.pdf)

**Can homeowners install their own ‘laundry to landscape’ graywater systems?** Yes, but installing a system correctly requires time to acquire the necessary knowledge as well as knowing what components to purchase and where to locate them. Before starting, it is wise to consider enrolling in a ‘how to’ class offered by local government jurisdictions. ‘Greywater Action’ is a non-profit consortium that provides training on the design and installation of graywater systems to interested individuals, companies, and agencies. The ‘Greywater Action’ website contains a list of upcoming workshops as well as a list of trained personnel who have completed their training course. <http://greywateraction.org/business-directory/>. Other useful websites that detail design and installation are [oasisdesign.net](http://oasisdesign.net) and the San Francisco Design Manual: <http://sfwater.org/modules/showdocument.aspx?documentid=55>



Example of a residential landscape irrigated by a graywater system (source: sunset.com).

## Larger Scale, Complex Graywater Systems



Complex, multifaceted graywater systems using pumps, filters, and even ‘Smart Controllers’ linked to weather stations to target irrigations based on real-time plant water needs are now being used to irrigate expansive plantings at apartment, condominium, and other facilities. These systems require permits. Due to the required plumbing, pumping, filtering, energy requirement and overall cost their use is generally not justified in single family households with fewer than four or five residents. However, while the cost to design and install these systems can be high, their flexibility and efficiency often outweigh these disadvantages on large scale sites.

Sand-filtered drip systems are excellent examples of these high technological systems that fill a distinct and important void in the area of graywater reuse and water conservation. Graywater is temporarily stored in a tank with an effluent pump until it is needed for irrigation. Hair, lint, and other debris must first be filtered out before the graywater can be run through tubing and emitters without clogging the system. An obvious advantage of these systems over simple mulch basins that require digging of trenches in root zones of trees is that root damage is prevented and tree roots are not prone to circling and girdling in the mulch area over time. Other advantages are that these systems can irrigate uphill, downhill, and at level elevations, are fully automated and can be used in conjunction with ‘Smart controllers’ and in most cases use all graywater generated. (If too little graywater is available potable water can be temporarily piped through the system instead.)

For specific information on plan preparation, design, construction, and management of complex graywater irrigation systems, contact the American Society of Irrigation Consultants (ASIC) <http://www.asic.org/> or the Irrigation Association <http://www.irrigation.org>.



Casa Dominguez, an affordable housing development in Los Angeles, uses washing machine-generated graywater to irrigate its landscape (source: CA planning and development report).

## **Benefits and Risks of Using Graywater Systems**

Specific benefits of using graywater to irrigate California landscapes include:

- reduced reliance on potable water sources to irrigate landscapes,
- reduced energy load otherwise required for pumping and treating potable water,
- a sustainable, steady, and reliable water harvesting source in areas of the state with low rainfall where the potential for rain harvesting is negligible.

Along with many potential benefits come potential risks, which should be carefully evaluated before deciding whether to install a graywater system. Graywater varies substantially in quality and potential risks from site to site. Without adequate natural rainfall, any system (including graywater) that discharges wastewater into garden soil can potentially add damaging concentrations of salts to the soil which can negatively impact plant health. Many household cleaning products, as well as many shampoos, soaps, and detergents, contain compounds which can pose significant human and environmental health concerns and can injure and even kill plants at high dosages over a short period of time. Others can cause significant damage from smaller dosages over a longer period. Products containing high levels of sodium should not be used in 'laundry to landscape' systems and accumulated salts may need to be leached regularly through the soil. Products high in sodium include some detergents, whiteners, and water filtered through softener systems. In general, liquid detergents are lower in sodium and therefore preferred over powdered products. Chlorine-based bleach should be avoided; oxygenated bleaches containing hydrogen peroxide are an excellent alternative.

### **Impact of Graywater on Human Health**

Because of the recent changes regarding graywater reuse under California and other state statutes, research pertaining to the long-term impacts and risks of graywater reuse on human health, plant health, soil chemistry, and ground and surface water quality is very limited. An overview of current research-based information follows.

Research examining the microbial constituency of graywater indicates that direct contact with graywater can pose a health risk to humans. Pathogens can enter graywater through food sources in the kitchen, which is why use of graywater generated from kitchen sinks and dishwashers is not recommended. Also, because pathogens can enter graywater through fecal matter, water contaminated by dirty diapers should be avoided.

Pathogens posing the greatest concern in graywater include bacteria such as enterotoxigenic *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Vibrio cholera*, *Campylobacter* spp., *Clostridium perfringens*, *Legionella* spp.; protozoans such as *Giardia* spp. and *Cryptosporidium* spp.; and viruses such as enteroviruses, hepatitis A, rotavirus, and Norwalk virus.

Some contaminants and pathogens active in sewage and sewage effluent can be translocated to fruits and vegetables grown in proximity. Results from study to study vary widely. Several studies found that microbiological contamination in municipal wastewater used to irrigate agriculture crops can pose significant risks from viruses, bacteria and pathogenic protozoan/helminthes under certain conditions. A wide variety of growing conditions and maintenance practices as well as climate and microclimate influence adverse outcomes. Since

graywater can contain some of the same contaminants as raw sewage (although in lower concentrations) such as fecal coliforms, they can register above international drinking, bathing, and irrigation water standards. Graywater can also contain pathogens derived from food handling, and opportunistic pathogens found on skin. While to date there have not been any documented cases of graywater resulting in public health impacts, caution should be exercised since it is difficult to trace illness back to its source in many cases.

In any case, graywater should not be applied directly to edible plant parts or root crops. To be safe, it should be applied only to nonedible ornamental plants and splashing graywater on neighboring edible plants should be avoided. Graywater should not be applied through sprinkler systems, since droplets containing harmful microbes can become suspended in the air and inhaled.

### **Impact of Graywater on Soil Chemistry and Water Quality**

Limited research has addressed the fate of microorganisms found in graywater and their resulting impact on indigenous soil microorganisms, soil chemistry, and water quality. Infiltration through soil, rock, and other materials that serve as filters can significantly diminish the threat of water pollution from graywater use. Unfiltered graywater accumulating in surface water and graywater seepage into nearby wells can diminish water quality resulting in waterways pollution. Graywater, by California statute, cannot come in close contact with groundwater. The California plumbing code states, “no irrigation or disposal field shall extend within three (3) vertical feet (915 mm) of the highest known seasonal groundwater, or to a depth where graywater contaminates the groundwater, ocean water or surface water.” When graywater is applied per these provisions risks are greatly reduced and/or prevented.

### **Impact of Graywater on Plant Health**

Because graywater is often rich in nutrients required for plant growth, ornamental plants may benefit from its use. However, graywater may include high levels of sodium, potassium, and calcium which can increase pH (alkalinity). Since many California soils are alkaline (pH above 7.0) to begin with, soil tests should be conducted to determine if added sulfur is needed to reduce the pH to optimize growth of alkaline-sensitive plants. Ornamental plants vary dramatically in their sensitivity to the wide array of potentially harmful salts found in graywater, particularly over a long-term basis. In general, evergreen trees are more salt sensitive than deciduous trees. Very little is known regarding the impact of graywater use on annual bedding plants. More research is needed on the impact of graywater on plant health since the chemical composition of graywater is different than that of treated wastewater and surfactants are widely used in household cleaning products.

Regardless of what graywater system is chosen, the following precautions should always be taken:

- Carefully label all valves and pipes associated with your graywater system and prevent backflow.
- Do not store graywater more than 24 hours.
- Wear gloves and do not come into direct contact with graywater.
- Do not let graywater pool or run off of the soil surface or come into contact with well water.

- Do not irrigate edibles with graywater or allow it to splash on neighboring edible plants.
- Do not irrigate turfgrass or ground cover areas with graywater, since potentially harmful microorganisms can remain on the surface.
- Do not use graywater contaminated with human waste, infectious disease organisms, grease, paint residue, gasoline, solvents, or other chemicals found in household and industrial products.
- Keep the graywater system simple and avoid systems requiring heavy upkeep and maintenance. Contact a professional with experience designing and installing graywater systems if you lack the specific skills required for design and installation.

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