

On-site wastewater treatment systems

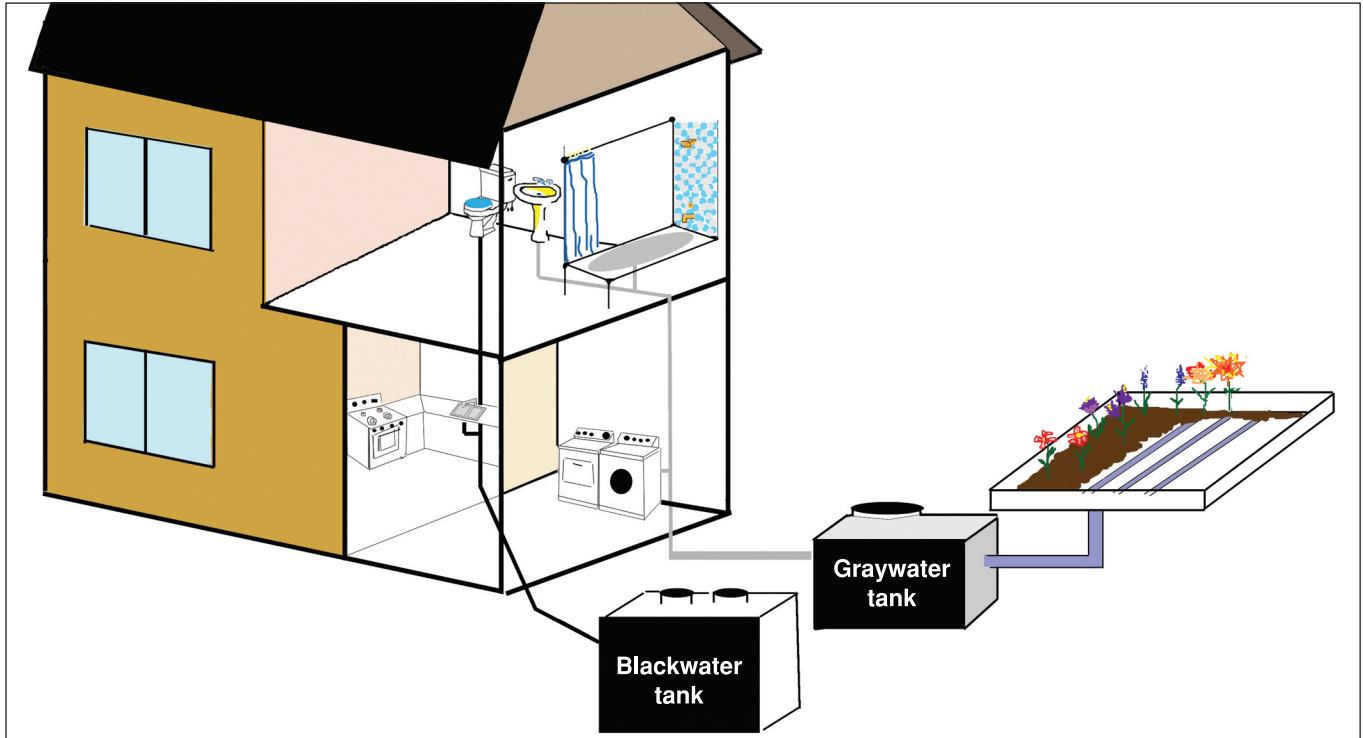


Figure 1: A diagram of separate blackwater and graywater plumbing systems.

Graywater

Bruce Lesikar¹, Rebecca Melton², David Smith² and Courtney O'Neill²

¹Professor and Extension Agricultural Engineer; ²Extension Assistant,
Biological and Agricultural Engineering Department
The Texas A&M University System

With water reuse gaining popularity, people increasingly consider graywater from their residences as a resource to be separated from the wastewater stream and reused in their landscapes. Such reuse of graywater reduces the amount of wastewater entering sewers or onsite wastewater treatment systems, reduces demands to use potable water for other residential uses like irrigation and helps preserve limited water supplies for essential uses like human consumption. This publication discusses using graywater resources simply and legally, at the same time protecting your family's health, your neighborhood and the environment.

Historically, graywater reuse in Texas was limited to reusing laundry water, as homeowners disconnected

such laundry water from wastewater drainpipes and diverted its flow to lawns. However, some jurisdictions

prohibited graywater reuse. In 2003, the 78th Texas Legislature passed House Bill 2661, providing guidance on residential graywater system with a capacity less than 400 gallons per day. This legislation paved the way for broad-scale graywater reuse in the state and sought to ensure that water to be reused would be collected, stored and discharged responsibly to protect users' and their neighbors' health and the environment.

To ensure personal and environmental safety, House Bill 2661 also instructs the Texas Commission on Environmental Quality (TCEQ) to create regulatory

guidance for graywater use. Regulatory guidance for graywater flows is presented in Title 30 of the Texas Administrative Code, Chapter 285. In Texas, local authorities generally do not issue permits for systems from single family residences with daily graywater flow of less than 400 gallons.

Residential wastewater sources

Residential wastewater can be divided into *blackwater* and *graywater*, depending on its source. The Texas Water Code (Code) defines **graywater** as water discharged from

- ✓ showers
- ✓ bathtubs
- ✓ handwashing lavatories
- ✓ sinks (not used for disposal of hazardous or toxic materials)
- ✓ sinks (not used for food preparation or disposal)
- ✓ clothes-washing machines

The Code's definition excludes water discharged after washing materials soiled with human excreta (e.g., diapers) and wastewater that has contacted toilet waste.

Blackwater contains relatively higher concentrations of nitrogen, organic matter and human pathogens than does graywater. Blackwater includes flush water from toilets and urinals and wastewater from food preparation sinks. Fig. 1 illustrates average daily percentages of graywater and blackwater from various sources.

Graywater separation

To be reused, graywater first must be separated from blackwater, upstream of any treatment systems. Such separation must be done both

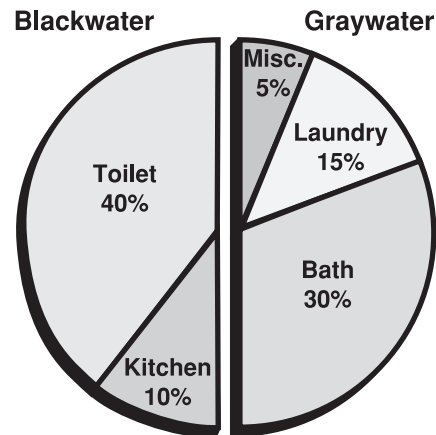


Figure 1. Wastewater from blackwater and graywater sources, by percentage.

for households equipped with onsite wastewater treatment systems and for those plumbed into municipal sewer systems.

Diversion splits blackwater from graywater using two separate pipe collection systems inside a house, running to appropriate fixtures (Fig. 2). Toilet water can be treated with technologies such as non-discharging toilets (incinerating and composting) or can be directed to a separate onsite wastewater treatment system. Once separated, graywater can be diverted for reuse, such as for landscape irrigation, or it can be directed first to an onsite wastewater treatment system for further treatment. Fig. 3 illustrates the four primary components of an onsite wastewater treatment system. Graywater diverted by a separation system would be introduced upstream of its collection and storage components of the onsite wastewater treatment system.

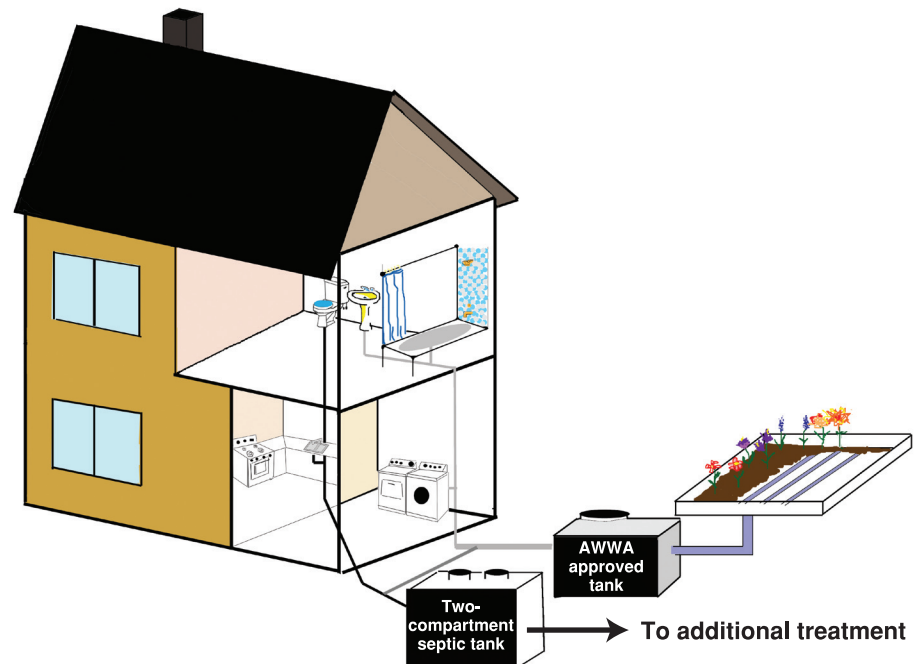


Figure 2. House diagram of separate blackwater and graywater plumbing systems.

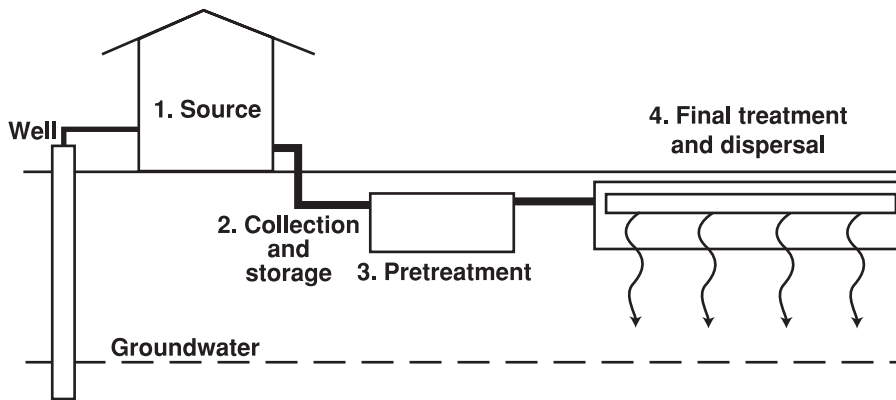


Figure 3. Components of an onsite wastewater treatment system.

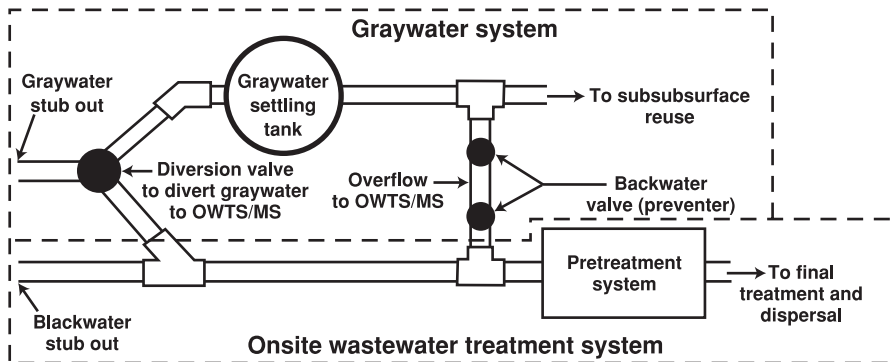


Figure 4. Diverted graywater plumbing system.

Diverted plumbing systems require separate management of blackwater and graywater sources. Because graywater systems may be used seasonally, may need periodic maintenance, or may be abandoned in the future, a diversion valve should be placed in the graywater collection line at the point where it leaves the residence (Fig. 4). This diversion valve allows graywater flow to be directed to the graywater system or to the onsite wastewater treatment system (OWTS). If a residence is connected to a municipal wastewater treatment system, the diversion valve will direct graywater either to the graywater system or to the municipal collection system.

Overflow from the graywater system must be diverted to the onsite

wastewater treatment system or to the municipal system, but two backwater valves must be installed. A backwater valve (Fig. 5) allows water to flow one way (to the onsite wastewater treatment system or to a municipal sewer) but prevents effluent from

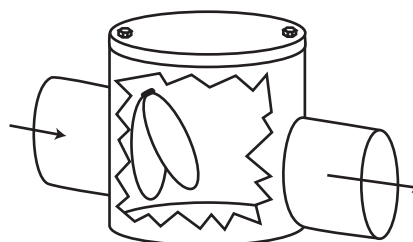


Figure 5. Backwater valve for plumbing into graywater system overflow line.

backing up into the graywater system. Water flowing in the desired direction has enough pressure to lift the flap of the backwater valve and pass through it, but sewage flowing the wrong way forces the flap to stay closed. Two valves are used as a precautionary measure, so that just in case one fails, sewage still cannot back up into the graywater system.

Graywater can be collected, treated, stored and reused. The type of wastewater-treatment system chosen depends on the constituents present in the graywater and on the level of treatment desired. In some cases, a settling tank with a gravity-fed pipe to the distribution system may be adequate (Fig. 6). In other cases, graywater can be sent to a secondary tank from which

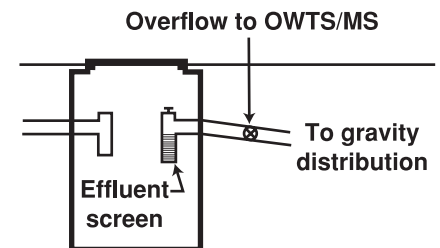


Figure 6. Settling tank for gravity graywater-distribution system.

it will be pumped to a pressurized subsurface reuse system (Fig. 7). In a pressurized system, discharge is regulated to control graywater application. Such control can be important when graywater is reused for irrigation.

With either design, an overflow pipe must be installed to divert excess water to the onsite wastewater treatment system or to the municipal sewer system. When an onsite wastewater treatment system is used, however, it may be easier to treat all wastewater from a residence for reuse rather than treat graywater separately. A decision to divert, collect or treat graywater

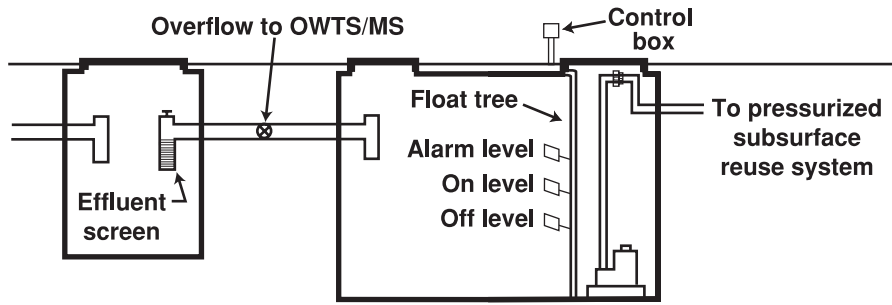


Figure 7. Settling tank and pump tank for pressurized graywater distribution.

or to separate wastewater streams at all should be based on an individual household's circumstances and on the purposes for which graywater will be reused.

Graywater system design considerations

Graywater sources

A homeowner first must decide which household graywater sources to collect for reuse. Collecting graywater from all sources increases the risk of additional solids and other pollutants being added to the graywater. Each source contributes different contaminants due to its particular water com-

position (Table 1). Constituents likely to be found in a particular graywater source should be compared to the intended reuse application for water from that source. Such evaluation also helps to identify treatment necessary prior to graywater reuse.

Graywater yields

The amount of graywater a household generates depends on number of occupants, their ages, their lifestyle characteristics and their water-use patterns and on the potential graywater sources to be fed into the system (Table 2). Total amount of graywater produced varies from site to site and must be estimated as part of system-design processes.

Graywater collection and storage

In a limited number of situations (system in existence prior to January 6, 2005), graywater from residential clothes-washing machines may be discharged onto the ground using a gravity flow system. Graywater from other sources should be diverted through settling tanks and pump tanks for later treatment and distribution. However, graywater contains organic matter, and if it is stored, it will quickly turn septic, generate offensive odors and promote growth of pathogenic microorganisms. Thus, it is critical to size the graywater settling tank and pump tank appropriately, so that they do not hold graywater for extended periods of time. Generally, to keep graywater fresh, it should be stored for less than one day, a critical consideration if it is to be dispersed onto the ground surface.

Texas graywater rules also require that graywater be collected in an approved tank that

- ✓ is labeled clearly as “non-potable water”;
- ✓ restricts access, especially to children;
- ✓ eliminates habitat for mosquitoes and other vectors;

Table 1. Constituents of wastewater from different sources (Wright, 1996).

Water sources	Bacteria	Bleach	Food particles	Grease and oil	Hair	High pH	Hot water	Nitrogen	Odor	Organic matter	Phosphorus	Salinity	Soap	Sodium	Suspended solids	Turbidity
Shower and bathtub	•			•	•		•		•				•		•	•
Sinks (other than kitchen)	•			•			•		•	•			•		•	•
Laundry		•		•		•	•	•		•	•	•	•	•	•	•

Table 2. Estimated residential water use based on house size.

No. bedrooms	Size of house (square feet)	Daily water use (gallons)	
		Without water-saving devices	(50%) Daily graywater production (gallons)
1 or 2	Less than 1,500	225	113
3	Less than 2,500	300	150
4	Less than 3,500	375	188
5	Less than 4,500	450	225
6	Less than 5,500	525	263

- ✓ can be cleaned; and
- ✓ meets structural requirements of the 2004 American Water Works Association (AWWA) standards.

Settling tank and pump tank capacities must be adequate for estimated graywater production, expected storage time and reuse application. The graywater settling tank should hold about one day’s production volume to limit graywater detention in the tank to less than a day and to collect gross solids on the tank bottom. Inlet and outlet pipes can be close together to allow fairly direct flow between them. An effluent screen should be placed in the outlet piping to collect debris that might otherwise exit the settling tank with discharged graywater.

Pump tank capacity is determined based on the pump’s minimum operating level, dose volume and alarm volume. These three factors usually equate to a pump-tank minimum volume equal to two days of flow, assuming graywater will be dosed to a distribution system daily. However, pump tanks may be larger, based on your landscape irrigation schedules. Some individuals may choose to irrigate only a couple of times a week, requiring larger tank capacity.

Graywater distribution

Approved reuse applications.

Texas graywater regulations allow graywater to be reused in the following ways:

- ✓ around the foundation of a new house to minimize soil movement or cracking;
- ✓ for gardening;
- ✓ for composting; or
- ✓ for landscaping at a single family residence.

To determine the most appropriate use for graywater, consider the constituents expected to be in the water, the constituents to be removed during treatment processes, and the amount of graywater available for distribution. For example, graywater used to maintain moisture around foundations would require less treatment than would graywater used to irrigate salt-sensitive trees or specimen plants.

Texas graywater rules dictate acceptable methods of graywater distribution. Generally, graywater should be applied subsurface. Distribution of graywater using a spray system is for-

bidden. Other good-sense guidelines help protect human and environmental health:

- ✓ Edible root crops probably should not be irrigated with graywater.
- ✓ Use graywater for well-established plants rather than for seedlings.
- ✓ Graywater usually is slightly alkaline, so avoid using it to water plants that thrive in acidic soils.
- ✓ To prevent salt accumulation, distribute graywater over a large surface area and rotate distribution from one area to another.
- ✓ Select reuse applications appropriate for the amount of water to be generated in the system.

Surface discharge exemption.

Texas regulations include special rules for laundry graywater systems in use before January 6, 2005. According to 30 TAC Chapter 285 Subchapter H. Section 285.81, a homeowner that has been discharging laundry water directly onto the ground surface (without a settling tank) since before January 6, 2005, may continue to do so if the area onto which the laundry graywater is applied

- ✓ does not create a public health nuisance,
- ✓ supports plant growth or is sodded with vegetative cover,
- ✓ does not have wet soil,
- ✓ does not have surface ponding, and
- ✓ has limited access and use by residents and pets.

This rule also states that a discharge line must have a lint trap and that use of detergents with significant amounts of phosphorus, sodium or boron should be avoided. If at any time the system is altered, creates a nuisance or discharges water from sources other than a clothes-washing machine, a previously exempt laundry graywater system will no longer be authorized to discharge to the surface. Such laundry water then must be directed to a graywater system meeting current regulations or into an onsite wastewater treatment system.

Graywater systems installed after January 6, 2005, must follow the criteria of Section 285.81 that allow for discharge above the surface so long as provisions of this section are met. Under this rule, washing-machine discharge first must pass through a graywater settling tank, and the surface drag hose or piping must be purple to denote a nonpotable water conduit (Fig. 8). This color requirement can be met by using pipe painted purple, purple pipe or pipe taped with purple metallic tape. Homeowners should discharge graywater to the surface only from systems for which laundry graywater is the exclusive source. If a homeowner desires to discharge graywater for surface reuse, other than from a laundry system, he or she can install a graywater or secondary treatment system complying with all rules for onsite wastewater treatment systems as listed in Chapter 285 regulations.

Subsurface distribution. Although surface discharge (except for spraying) is allowed for treated graywater, graywater reuse should be distributed strictly below the soil surface to

minimize potential health risks and odors. An example of subsurface distribution includes graywater dosed to a gravel bed or trench underlying a flowerbed (Fig. 9); water not taken up

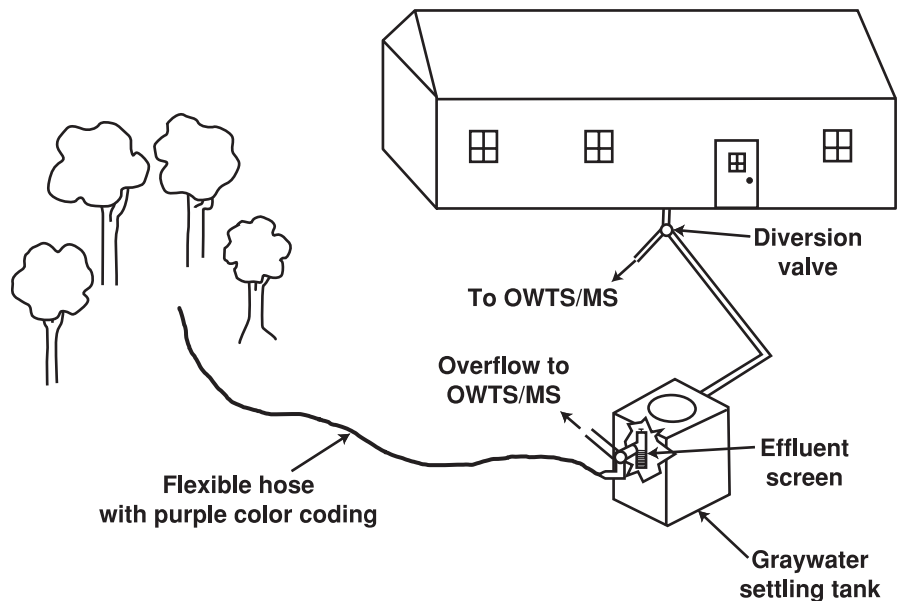


Figure 8. Laundry graywater system with small settling tank and drag hose for irrigation.

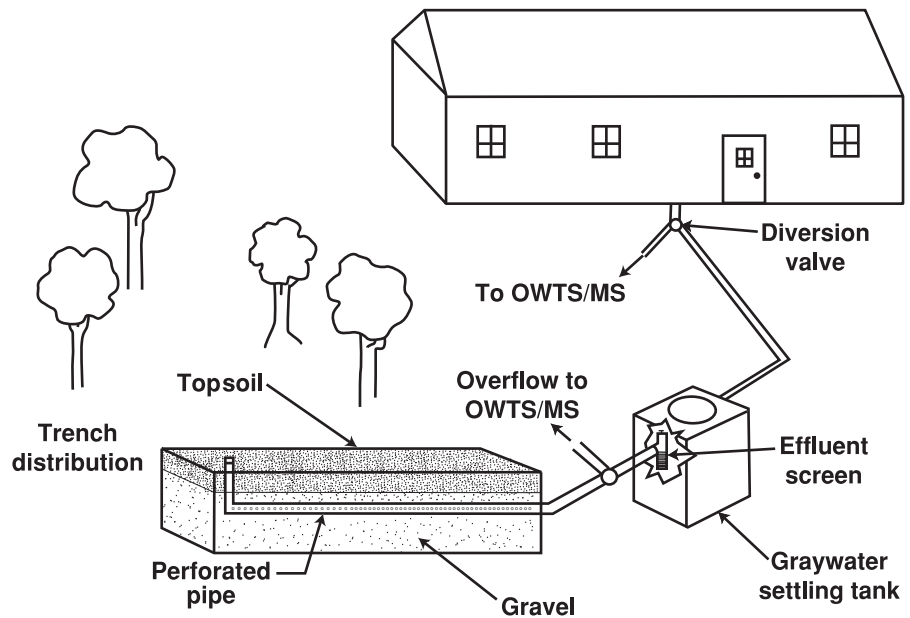


Figure 9. Graywater system with gravity distribution through a gravel media trench.

by plants then percolates through the soil profile. The soil provides water treatment through physical (filtration), chemical (adsorption and transformation) and biological (degradation and predation) processes to kill off harmful pathogens.

Graywater systems equipped with pump tanks can disperse water through a pressurized subsurface drip system to irrigate trees, flowerbeds and planter boxes (Fig. 10). If graywater will be used for irrigation, it is important to know how much water will be available for reuse, so that the irrigation system can be sized accordingly. Reuse system design also should consider typical supplemental water requirements of plants, espe-

cially during peak water-use months. Graywater reuse alone may not be sufficient to meet plant peak-water needs for high-water-use lawns, but it may provide enough water for small flower beds and planter boxes.

An in-line filter should be installed to remove any particulate matter that might clog discharge pipes or irrigation emitters. The filter type needed depends upon amount of graywater to be filtered and types of contaminants expected. No matter what filter type is used, it should be cleaned periodically in order to prevent it from clogging or reducing flow to irrigation fields. Automatic backwashing filters are available and can limit clogging risks.

Regulations regarding graywater systems do not provide specific guidance on distribution-system sizes, so designers can size a system based either on irrigation requirements or on soil absorption.

If system size is based on irrigation requirements, distribution areas must be designed to meet summer-month water requirements for landscape plants. During winter (or in lower-water-use months), graywater must be diverted to an onsite wastewater treatment system or a municipal sewer to prevent oversaturating the soil, resulting in less treatment of the graywater.

Distribution-system sizing based on soil-absorption requirements may not

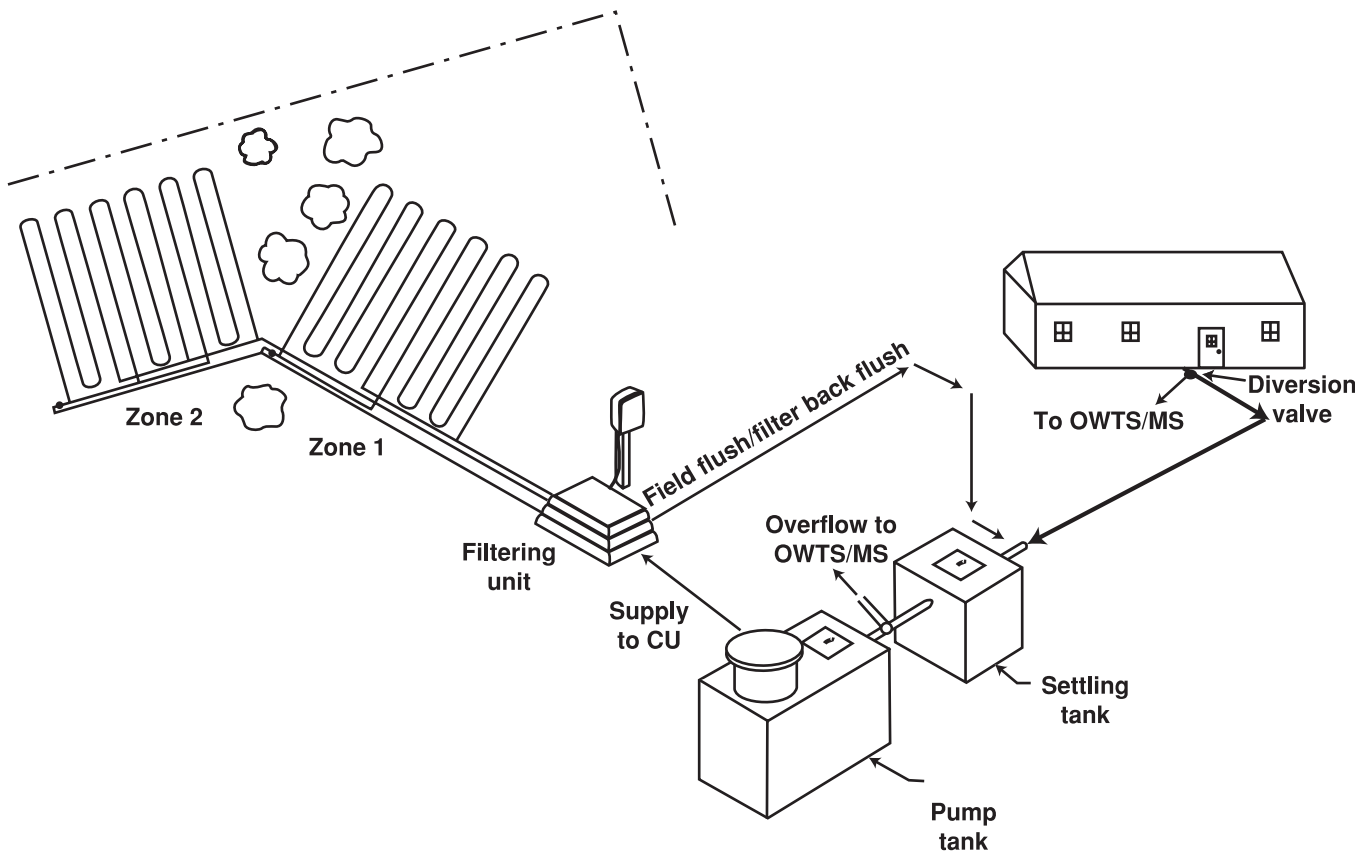


Figure 10. Graywater system using pressurized distribution in a subsurface drip system.

meet plant water requirements during peak-water-use months. However, such sizing can follow the guidelines for the soil-absorption component of an onsite wastewater treatment system. These sizing guidelines are based on type of soil accepting the wastewater and present the long-term acceptance rate of the soil based on its classification into four texture-types with specific long-term acceptance rate for each classification (Table 3).

Distribution-trench area or drip-distribution area can be estimated using these sizing factors. Divide graywater-system-designed-flow by the appropriate soil sizing factor to determine distribution-system required square footage. (Soil must be present around the trench or drip distribution system to accept and treat the graywater, reducing risks of contaminants reaching our water resources.)

Required Distribution Area (ft²) = Design Flow (gal/day) ÷ Acceptance Rate (gal/ft²-day)

For example, to distribute a graywater flow of 300 gallons per day on a sandy loam soil would require a distribution area of 1,200 square feet.

Required Distribution Area (ft²) = 300 gal/day ÷ 0.25 gal/ft²-day

Required Distribution Area = 1,200 ft²

Advanced systems are available solely for treating graywater. However, instead of spending money on such a treatment system, it may be more cost effective to forgo a graywater system all together and upgrade your onsite wastewater treatment system to a level that can produce effluent meeting water-quality standards for surface or drip reuse (30 TAC Chapter 285).

Safety concerns

To protect yourself, your family and your pets, you must understand that what is washed down sinks and showers into a graywater reuse system will eventually end up in your yard. Following are a few safety tips to consider when using such systems:

- ✓ If a resident of your home comes down with a contagious sickness, it may be wise to divert graywater from the house to an onsite wastewater treatment system or to a municipal sewer until that individual has recuperated. Otherwise, anyone coming into contact with

graywater could be exposed to disease-causing organisms.

- ✓ Water used to launder clothing soiled by pesticides or other toxic substances should not be discharged into a graywater system.
- ✓ As with any water treatment system, regular operational and maintenance checks must be performed.
- ✓ If anyone becomes ill after exposure to graywater disposal areas, discontinue using your graywater system until you have determined the source of the illness.

Municipal wastewater treatment systems

The preceding information about using advanced graywater treatment has been directed toward households not connected to municipal sewer systems. Homes connected to sewer systems can install additional subsurface graywater-reuse systems and/or laundry- graywater systems. Texas regulations for such systems are found in Title 30 of the Texas Administrative Code Chapter 210, Subchapter F and are nearly identical to those described in Chapter 285. The only differences between these code sections are specifications in Chapter 210 that (1) graywater can be diverted to an organized water collection system, rather than to an onsite wastewater treatment system as mentioned in Chapter 285 and (2) graywater-system construction, including storage and disposal components, must comply entirely with Chapter 210.

Table 3. Long-term acceptance rates for different soil types.

Soil classification	Long-term acceptance rate (gal/ft ² -day)
Class Ib (sand, loamy sand)	0.38
Class II (sandy loam, loam)	0.25
Class III (sandy clay loam, sandy clay, clay loam, silty clay loam, silt loam, silt)	0.20
Class IV (silty clay, clay)	0.10

Minimizing blackwater generation

Using composting or incinerating toilets in a home dramatically decreases the blackwater-waste stream. Sinks used for food preparation or disposal are considered blackwater sources. Therefore, a wastewater treatment system still is needed for the kitchen-sink flow. This type of reuse-treatment system then would be treated as an onsite wastewater treatment system, falling under the rules in Chapter 285.

Maintaining a graywater system

To keep them working properly, all treatment and reuse systems require some level of attention to their operation and maintenance. The system's designer should provide specific guidelines for maintaining your system. Some general guidelines follow:

- ✓ Clean the effluent screen at least annually. Remove the screen and spray residuals off into a large bucket. Once the effluent screen has been replaced into the settling tank outlet, slowly pour washwater back into the settling tank.
- ✓ Remove accumulated solids from the settling tank. Contact a wastewater pumper to pump out the solids. Remove solids when they occupy about 25 percent of the tank's depth or about every 3 to 5 years.
- ✓ The graywater system may not be needed during the entire year. During seasons it is not used, set the diversion valve to direct flow to the onsite wastewater treatment system or to the municipal sewer.

- ✓ If you use a laundry-graywater surface-discharging system, periodically move the drag hose to prevent graywater from ponding in the landscape.
- ✓ If you use a pressurized system, periodically replace the pump as it fails.
- ✓ The particular technology you use to distribute graywater will have specific operation and maintenance requirements. More information on servicing a particular technology is available from Texas Cooperative Extension's onsite wastewater treatment fact sheet series. It can be accessed from the Web at <http://ossf.tamu.edu>.

Summary of Texas graywater regulations

Texas Administrative Code Title 30, Chapter 285 Subchapter H, Section 285.80.

This section lays out general requirements for graywater. It gives the definition of graywater used above and notes that all construction of graywater systems must comply with the guidelines of Chapter 285, as well as with any more stringent requirements set by local permitting entities.

Texas Administrative Code Title 30, Chapter 285 Subchapter H, Section 285.81

This section defines criteria for disposal of graywater. An onsite graywater system is not subject to permit

or inspection if it conforms to the following guidelines:

- ✓ Less than 400 gallons of graywater are used each day for domestic purposes.
- ✓ The graywater must come from a single-family dwelling.
- ✓ The system must be designed so that 100 percent of the graywater can be diverted to the owner's onsite wastewater treatment system through two backwater valves or backwater preventers; these connections must be located in the line between the house stub-out for the onsite wastewater treatment system and the onsite wastewater treatment system pretreatment tank.
- ✓ The graywater must be stored in tanks:
 - that are labeled clearly as non-potable;
 - that have restricted access;
 - that eliminate habitat for vectors;
 - that can be cleaned; and
 - that meet the structural standards of the 2004 American Water Works Association (AWWA) standards. (Look for a stamp indicating the tank meets AWWA standards.)
- ✓ The graywater system must use piping that identifies the water as non-potable; such piping may be purple pipe, pipe painted purple or pipe taped with purple metallic tape.
- ✓ The graywater should not be applied at a rate that may result in ponding, pooling or runoff across property lines or onto paved surfaces.

- ✓ The graywater may not create a nuisance or damage the quality of surface water or groundwater.
- ✓ The graywater cannot be disposed of using spray distribution.

If any of these requirements for a graywater system are not met, the system must meet the requirements for an onsite wastewater treatment system, as described in the rest of Chapter 285. Installing a graywater system does not allow reduction in the size of the onsite wastewater treatment system. Graywater may be used around the foundation of a new house to minimize movement or cracking or

for gardening, composting or landscaping at a private residence. The installer of the graywater system must instruct the owner on basic operating and maintenance procedures, including the system's effects on an onsite wastewater treatment system. All Texas Commission on Environmental Quality (TCEQ) rules and regulations can be accessed from the Web at <http://www.tceq.state.tx.us/rules/indxpdf.html>.

References

Texas Administrative Code Title 30
Chapter 285, Texas Commission on
Environmental Quality

Texas Administrative Code Title 30
Chapter 210, Texas Commission on
Environmental Quality

Wright, M. 1996. Safe use of household graywater. Guide M-106. Las Cruces, NM: Cooperative Extension Service, New Mexico State University.

Acknowledgment

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 2005-45049-03209.

The On-Site Wastewater Treatment Systems series of publications is a result of collaborative efforts of various agencies, organizations and funding sources. We would like to acknowledge the following collaborators:

Texas State Soil and Water Conservation Board	USEPA 319(h) Program
Texas On-Site Wastewater Treatment Research Council	Texas AgriLife Extension Service
Texas Commission on Environmental Quality	Texas AgriLife Research
USDA Water Quality Demonstration Projects	Texas On-Site Wastewater Association
Consortium of Institutes for Decentralized Wastewater Treatment	USDA Natural Resources Conservation Service

Produced by AgriLife Communications and Marketing, The Texas A&M System
Extension publications can be found on the Web at: <http://AgriLifebookstore.org>

Visit the Texas AgriLife Extension Service at <http://texasextension.tamu.edu>

Educational programs of the Texas AgriLife Extension Service are open to all people without regard to race, color, sex, disability, religion, age, or national origin.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas AgriLife Extension Service, Texas A&M System.

2M, Reprint
