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Introduction to Continuing Education Class on Graywater and Private Onsite Wastewater Treatment Systems for Utah Plumbers (Video)

Hello and welcome to this class on plumbing-industry-related topics. This class will be looking at two different topic that share some elements - graywater collection and reuse systems and private onsite wastewater treatment systems.

The first part of the class will look at graywater. But before we get into this topic, let's settle one pressing issue when it comes to graywater – how do you spell it? Is it all one word or two and is gray spelled "g-r-a-y" or "g-r-e-y"? First – let's be clear that the two spellings of gray are both correct and have no difference in use or meaning. England sticks to g-r-e-y, but the g-r-a-y spelling is more common in the U.S., so that's the one we'll use. For the same reason, because of the American tendency to turn two-word terms into one, like we did with smartphones and wastewater, we'll make graywater into a single word, unless we're quoting from a law or code, in which case we'll usually spell it however they do.

If you wonder why I even bring up this issue, it's to underline just how relatively new and how rapidly changing this field is within the plumbing professions. It's only in the past decade or so that many states have overcome their reticence and started to provide rules, guidance, and even, in some cases, encouragement for the installation of wastewater capture and reuse systems. Prior to that, tens of thousands of folks across the nation had just gone ahead and – in that great American tradition – did it anyway, designing and installing their own graywater systems in what could be called a legal "gray area". That situation remains true in a number of U.S. states, but the trend is clear that graywater systems are increasingly coming under regulation. What this means is that the systems will become more sophisticated, safer, more robust, and more likely than ever to be designed and installed by licensed plumbers. In particular, graywater systems are becoming a desirable feature in some new home construction, since they don't face the challenges that arise when you try to retrofit existing plumbing for a graywater system.

Only the first half of this class will discuss graywater. The second half of the class will look at Private Onsite Wastewater Treatment Systems. Unlike graywater installations, these systems are NOT intended for water reuse but for handling and disposal of sanitary drainage when no public sewer connection is available. Although the issues faced are very different from those with graywater systems, the two would work together nicely if they are both installed at the same site, since the graywater system can substantially reduce the amount of effluent that the Onsite Treatment System needs to handle. Graywater and Onsite Treatment are complementary offerings for a plumbing business who wishes to add both systems to his or her practice.

We'll start with a discussion on the Principles of Graywater Systems.

[VIDEOBOTTOM]

[SLIDECUT]

[QUESTIONHEADER]

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Which of the following represents how this term is to be spelled in this class (unless spelled differently within cited codes and rules)?	Graywater	Gray water	Grey water	Greywater

[QUESTIONBOTTOM]

[SLIDECUT]

Principles of Graywater

The first rule of graywater system design is that there is no one rule. Graywater capture and reuse is highly context-specific. It's designed around the space, for the living style of the occupants, founded in trade-offs between cost and value, and tailored to achieve particular results in a particular environment.

Nevertheless, there are principles that can be adapted to suit particular situations. The principles we'll discuss in this lesson lay the foundation on which the context-specific design and installation of a graywater system can be built.

Introduction

The world isn't running out of water. With all the talk and concern about future water shortages, it's worth pointing out that there is more or less the same amount of water on Earth as there was millions of years ago. Likely – barring some unthinkable disaster – there'll be more or less the same amount of water on Earth millions of years from now. Unlike copper, oil, etc., water is a renewable resource. The problem, then, is not having too little water but where the water is. About 97% of the world's water is contained in the oceans. Another 2.7% is frozen, underground, or in the atmosphere and (at least for now) inaccessible. Of the less than 1% of the world's water on which all human, animal, and plant life depend, the distribution is wildly uneven. Some areas receive too much and may suffer floods while others receive too little and suffer droughts.

These uneven patterns have always existed but most climate scientists and hydrologists have concluded that the distribution of available water is becoming more uneven. At the same time, unprecedented population growth places rapidly multiplying demands on what water is available while pollution (or lead from old water pipes) makes an increasing portion of that water unhealthy for use. The popular saying, "You don't miss your water 'til your well runs dry," is not a sensible strategy for facing this challenge. Indeed, many analysts predict "water wars" will be caused by shortages and have termed water the "oil of the 21st century" in recognition of its potential for causing bloody conflicts.

Solutions

The good news is that the plumbers and plumbing manufacturers in the U.S. have been leaders in responding to these challenges. There are essentially two ways to decrease demand for delivery of fresh, potable water from water utilities to homes and businesses:

1. Water conservation; and

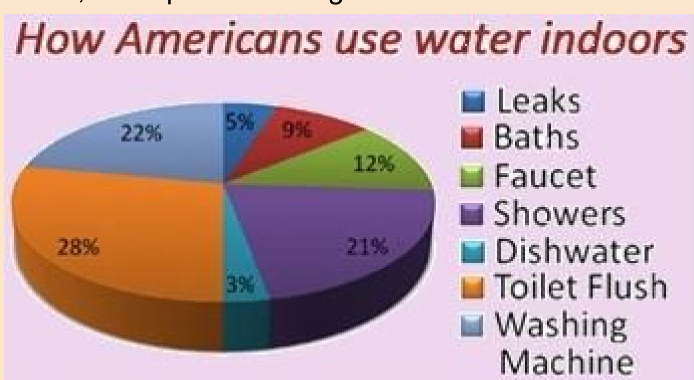
2. Alternate water sources.

The U.S. plumbing industry continues to make great strides with regard to conservation. We're installing low-flow toilets and showers, finding and fixing leaks, and helping educate the public on simple ways to save water (shorter showers, don't leave tap running when you brush your teeth, don't flush every time after urination, etc.)

Capitalizing on alternative water sources is more complicated. Rainwater catchment systems are growing quickly in popularity, but are still rare and not suitable to every climate. Graywater can provide even more water savings than rainwater, since it's more easily used in fixtures than rainwater as well as being available for irrigation. It also puts less stress on sanitary drainage systems. Graywater has the advantage over rainwater in that it's fairly steady and predictable and doesn't require large cisterns to store and use through drier months.

The quantity of graywater available is considerable. One estimate is that Californians produce 1 billion gallons of graywater daily. About ⅔ of the effluent from indoor water use in the average American home is graywater – more than twice the amount needed for toilet flushing. All of these numbers only reflect indoor water use. On average, the amount of fresh-water use for residential watering and irrigation is about equal to the amount consumed indoors, although the actual outdoor use by each home varies widely from less than 10% to more than 90% of all water used at that residence.

The average person generates over 25 gallons of graywater daily; a family of four produces enough graywater to irrigate over 2,400 square feet of garden in a semi-arid climate.



Figures from the E.P.A. 2010

Reasons to Use Graywater

The most common use of minimally treated graywater is to flush toilets and urinals, especially in high-rises, hotels, schools, office buildings, and large dwellings. With varying amounts of additional treatment (including such tertiary treatments as filtration, chlorination, or carbon filtration, etc.), graywater can also be used for the following purposes:

- Landscape irrigation;
- Cooling tower makeup;
- Decorative pool and fountain fill water;
- Floor and general hard-surface wash-down;
- Vehicle washing; and
- Laundry water supply.

The amount of treatment of graywater that would allow it to be used for potable purposes is considerable, but it is possible that it could even be practical in some locations. It almost always requires regulatory approval, which may be difficult to obtain without a good reason such as a protracted and widespread drought.

The advantages of graywater depend on the needs and desires of the person or company employing it. They may include:

- Lower water bills;
- Lower sewer bills or septic system costs;
- Pride in being water thrifty;
- Good public relations;
- Earning up to six LEED (Leadership in Energy and Environmental Design) points for 50 percent reduction in new construction water use.

Depending on the complexity of the system, the capital investment for graywater capture and reuse may pay for itself in less than two years and rarely takes more than five years to pay for itself.

What is Graywater?

Precise definitions of graywater vary from state to state and from plumbing code to plumbing code. A good example can be found in the 2015 Uniform Plumbing Code®:

> **UPC® graywater.** Untreated wastewater that has not come into contact with toilet waste, kitchen sink waste, dishwasher waste, or similarly contaminated sources. Graywater includes wastewater from bathtubs, showers, lavatories, clothes washers, and laundry tubs. Also known as grey water, graywater, and greywater.

The 2015 International Plumbing Code® is considerably more concise:

> **IPC® graywater.** Waste discharged from lavatories, bathtubs, showers, clothes washers and laundry trays.

The related term “Black Water”, although not code-defined, is widely accepted to describe any wastewater that is not suitable as graywater. A less-widely used framework adds “Dark Graywater” which would serve as a bridge between the other terms, as follows:

Graywater is household wastewater that includes the following:

- Shower water
- Bath water
- Lavatory and wash basin water
- Laundry water
- Untreated spa water

Dark Graywater is household wastewater from the kitchen, which may contain food contaminants, oils, and powerful detergents (especially if from a dishwasher). Although many jurisdictions ban the use of kitchen water as graywater, this water could still be used for garden irrigation IF a grease trap is installed between the kitchen waste outlet and any treatment/irrigation systems.

Blackwater is household wastewater that includes:

- Water flushed in toilets, urinals, and bidets

- Laundry water, if it’s from washing diapers or other materials with fecal contaminant

Basic Rules

Good, Bad, and Ugly [Contaminants]: Graywater may contain traces of dirt, food, grease, hair, and household cleaning products. The easiest way to use graywater is to pipe it directly outside and use it to water ornamental plants or fruit trees. While graywater may look “dirty,” it’s safe and even beneficial as irrigation water – those little bits floating in the water can break down into nutrients in the soil, which plants love. As one writer put it:

> “Plants and soil are fine with funky, chunky water; it is pipes and people who may have a hard time with it. Pretreatment is only necessary to overcome limitations of the distribution plumbing to handle funky water. With a properly designed system, even straight kitchen sink water (very high suspended solids) can be reliably and safely distributed with no filtration whatsoever.”

There’s no advantage to using fresh potable water for gardens, even for vegetables or fruit trees. The top level of soil readily treats graywater, removing bacteria and contaminants. Some codes ban use of graywater on plants intended for consumption, although (in fact) graywater can also be used to irrigate vegetable plants as long as it doesn’t touch edible parts of the plants. For that reason, some municipalities ban its use to water root crops such as potatoes, onions, etc.

Far more concerning are the “clean” elements in graywater – residues of soaps, cleansers, detergent, cosmetics, etc. Salts, boron, chlorine, and other chemicals can cause plants to wither. There are numerous websites that can provide guidance on less harmful alternatives when those products could end up in graywater.

No Pooling: Codes forbid releasing more graywater for irrigation than can rapidly percolate into the ground. Pooling provides opportunities for human contact and breeding grounds for mosquitoes. Running off into streams or other water resources is also forbidden and can be minimized if the water isn't allowed to pool.

The 24-Hour Rule: The nutrients in graywater can break down quickly in suspension, resulting in unpleasant odors and propagation of bacteria. All codes set a 24-hour limit on storage; therefore, only a small (maximum 55 gallons) storage tank should be used when needing to retain graywater for later use in toilets, etc. *[Note: Treated graywater can be stored but, for most residential properties, the treatment systems required simply to allow for longer storage are not cost-effective.]*

Rules, Part 2

Simple is Sufficient: The more complicated a graywater system is, the more than can go wrong or need maintenance. Design a simple system and scale it to the need – overwatering is a common problem with graywater irrigation systems where some owners think more watering is always better, especially when it's free, but this can be harmful and diminishes the water savings ratio, since it's not replacing how much fresh water would be used once it goes past the needed amount of water.

Hands Off: Although not as dangerous as black water, graywater is still unhealthy. Health codes require precautions against any casual human contact with graywater.

Clear and Present: Every component used to transport and distribute graywater should be:

1. Conspicuously marked or labeled; and
2. Understood by users and potential users.

Blue, green, or purple lettering, labels, or piping colors are all in use for graywater pipes and taps, with purple being the most common as well as most often the color required by codes, where such requirements exist. All accessible components of the system should be marked or labeled both to warn the general public against accidental contact and to facilitate later work on the system. The owners and users should also be provided with any information (signage, manual, etc.) needed to avoid problems or contamination of fixture discharges, use the system properly, maintain it, and get the most out of it.

Economics

Some customers want a graywater system for its beneficial impact on the environment, compared to normal sanitary drainage systems that don't distinguish between gray and black water. Even these customers, however, will face economic variables that they'll weigh against the benefits. For those who are mostly concerned with how it can save them money, the economics of graywater systems becomes paramount.

Situations where graywater reuse makes the most sense are where municipal water supply is not available or where municipal sewer access is not available. The location where this may make economic sense is in an apartment, condominium, office, factory, or hotel large enough to benefit from the economies of scale.

A typical residential customer who installs a graywater system parallel to municipal water supplies might save $5-$20 a month. Any system that uses pumps, filters, treatment, long pipe runs, etc., would be difficult to justify, economically. The only way this type of customer could begin to save enough to make the system worthwhile is if there are extensive lawns and/or gardens and an adequate supply of graywater to irrigate them (particularly if the customer is subject to graduated level pricing that some communities use during droughts to discourage water waste or profligate use).

The other economic factor to consider is the dislocation that would be caused when installing these systems – the more elaborate the system, the greater degree of inconvenience. As mentioned earlier, when designed for a new home, the economics of a residential graywater system aren't nearly as daunting, but designing a retrofit should focus on priorities of application and on avoiding complex elements (filters, pumps, treatment, etc.) wherever possible.

On the other hand, in some locations, graywater systems are very worth installing. One plumber who installs these systems recounts his experiences:

"Acute disposal problems can change the picture. I got a call from one Alaskan oil camp where the graywater from several hundred people was boiled down to ash, and the drums of ash shipped to the continental US for disposal... Compared to this, almost any system would be cheaper, simpler and more ecological.

A hotel [in another example] was sending out their laundry at a cost of a few thousand dollars a month because they could not make a conventional on-site disposal system which could handle the water. A large, complicated, but well-built graywater system enabled them to do the laundry themselves, and they were able to pay off the investment in less than a year. Sheer volume shifts the economics drastically. Almost any institution with several thousand gallons a day of graywater production and a like amount of irrigation demand would find that a complex system capable of treating the water so it could be distributed efficiently through irrigation hardware could be paid off in a few months to a few years."

Health Concerns

The greatest hazard to health posed by a graywater system is cross-connection with potable water systems. For example, an irrigation system could use graywater but need to supplement it with potable water, providing a possible pathway for graywater to infiltrate the potable water system. Any potential path to cross-connection should have appropriate backflow protection and, where a substantial hazard exists, an alarm system may be considered.

Before we get carried away, it should be emphasized that the health risks posed by graywater (though they exist) are not a high risk, nor even a moderate risk. As of this writing, no disease outbreak has ever been linked to graywater. As long as sensible precautions are taken – such as avoiding aerosol transmission of bacteria by never emitting graywater through sprinklers (unless it has been suitably treated) – the chances of any serious health danger posed by graywater is negligible.

That being said, building and health department officials won't respond well if you dismiss their health standards and rules. Of greater concern, however, is that a graywater system that does not take adequate health precautions will allow unpleasant odors to infest the system and discourage use of the system.

Here is a list of the types of precautions suggested for graywater:

- ➔ Never use spray irrigation to apply graywater. Application of graywater must be done by utilizing a subsurface system.
- ➔ Apply the graywater to areas that receive little or no pedestrian traffic.
- ➔ Avoid irrigating edible fruit and vegetable gardens where the consumed portion of the plant rests on the ground.
- ➔ Never use graywater to wash down driveways, patios or other impervious surfaces.
- ➔ Wear latex or surgical gloves when handling components of the system to perform maintenance activities, such as cleaning filters.

- ➔ If someone in the home comes down with a contagious sickness, it may be wise to divert graywater from the house to the IWS or sewer system until that individual has recuperated. Otherwise, anyone coming into contact with the 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 wastewater treatment system, regular operational and maintenance checks must be performed.
- ➔ If anyone becomes ill after exposure to graywater irrigation areas, discontinue using the graywater system until the source of the illness is determined.
- ➔ Monitor the graywater irrigation area regularly and adjust graywater application rates, as needed, to ensure that ponding does not occur.

Graywater to Potable Water Treatment

As mentioned above, graywater is treated to the extent necessary for its intended use (and to be consistent with any applicable laws and code requirements). Typical treatments might include sedimentation, bioremediation, aeration, filtration, and disinfection. Depending on the type of filtration, the degree and types of contaminants removed vary. The simplest level of treatment (primary treatment) only requires filtering of all but very small solids – it reduces suspended solids but does not remove nitrates or phosphates. Secondary treatment means introduction of bacteria, such as in a septic tank. Direct tertiary treatment includes filtering the water to remove whatever solids remain, disinfection with chlorine or similar methods (which would also result in the inactivation of the type of bacteria in secondary treatment), and removal of salts. Indirect tertiary treatment is the passage through soil to groundwater during which the water is more fully filtered and disinfected than in almost any engineered system.

Most municipalities severely restrict any engineered system intended to go directly from graywater to drinking water. The primary purpose of graywater is in place of potable water where potability is not required, NOT as a replacement source of drinking water. Reverse osmosis filtering, which would be required to render the water drinkable, is essentially an engineered version of indirect tertiary treatment. On a space station or similar closed-system vessel, the expense of installing and maintaining these systems (including the costs of replacement filters) and the time involved in filtering are justified, but use in a typical home or enterprise would be very unusual.

When graywater is processed by municipal utilities or municipal programs for reuse, it is considered “recycled” water, not graywater. These utilities may use a combination of direct and indirect tertiary treatment which are not typically available to private citizens.

Laws and Rules

State-by-State Breakdown of Graywater/Wastewater Regulation					
States without Formal Graywater Regulations			States with Codified Graywater Reuse Rules		
States allowing wastewater reclamation that define graywater as wastewater	States not defining graywater	States treating graywater as septic	States permitting graywater using a tiered approach	States regulating graywater reuse without a tiered approach	States allowing residential irrigation only
Alabama	Illinois	Connecticut	Arizona	Florida	Hawaii
Alaska	Kansas	Kentucky	California	Georgia	Idaho
Arkansas	North Dakota	Maryland	New Mexico	Montana	Maine
Colorado	Ohio	Michigan	Oregon	Massachusetts	Nevada
Delaware	South Carolina	Minnesota	Washington	North Carolina	
Indiana	Tennessee	Nebraska		South Dakota	
Iowa		New Hampshire		Texas	
Louisiana		New Jersey		Utah	
Mississippi		New York		Virginia	
Missouri		West Virginia		Wisconsin	
Oklahoma				Wyoming	
Pennsylvania					
Rhode Island					
Vermont					

Table from "Treatment, Public Health, and Regulatory Issues Associated with Greywater Reuse. *Guidance Document*. By Sybil Sharvelle et. al. for WERF

As mentioned at the start of this class, laws and regulations across the U.S. are rapidly being developed and adopted. A few states still prohibit these systems; some residents of those states install systems nevertheless. A majority of states have no laws or rules that specifically apply to graywater; those states may have adopted a version of a model plumbing code. In these states, it's a good practice to check with local plumbing inspectors, building officials, and health department officials where you need clarity on which codes and rules apply. It should be noted that some states have one regulatory agency and set of rules for graywater used for internal fixtures and a different regulatory agency and set of rules for irrigation systems.

For those cities and states that have passed laws on graywater, the standards vary widely. For example, New Mexico's brief rules have a "tiered approach" that don't require a permit for systems that handle less than 250 gallons per day of private residential graywater originating from a residence for the resident's household gardening, composting, or landscape irrigation if 11 listed conditions are met, while San Francisco has an 84-page pdf to illustrate the rules and requires a permit even for simple systems unless they are a direct, integral connection from a washing machine to landscape.

The following states have adopted specific laws and rules on graywater systems: *[Note: Some of the information in the links, below, were compiled by justwatersaversusa.com as part of their online "Greywater Guide". Any information on this site should be considered illustrative and not definitive; the only current, definitive rules and statutes are those available through a website or other transmission means from the city or state.]*

- Arizona
- California
- Hawaii
- Montana
- New Mexico
- North Carolina
- Oklahoma
- Oregon
- Texas
- Utah
- Washington State
- Wyoming

[SLIDECUT]

[QUESTIONHEADER]

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According to the information provided in this class, what percentage of indoor fixture wastewater in an average residence is available for use as graywater?	Approximately 65%	Approximately 40%	Approximately 25%	Approximately 80%

[QUESTIONBOTTOM]

[SLIDECUT]

Design & Installation of Graywater Systems

Many graywater systems are NOT a system, per se, in that they aren't self-contained. Although some smaller systems are integral and dedicated systems, many others are actually a modification of the structure's overall water supply and drainage systems. Rather than all plumbing fixture discharge being transported by sanitary drainage to the sewer system, the effluent from selected fixtures is routed for recovery, treatment, and delivery by graywater system components. The remainder goes through the normal drainage piping to the sanitary sewer, including (of course), graywater after it has been used in fixtures. Wherever graywater is transported, stored, or used within the facility (indoors or outdoors), it must have its own run of water supply piping and fittings. Potable water piping to lavatories, sinks, baths, and showers, etc., often run alongside parallel graywater piping that serves water closets, urinals, irrigation systems, and other fixtures depending on local codes and the quality of the graywater treatment.

Wherever graywater is transported or stored within the facility (indoors or outdoors), it must have its own set of drainage and water supply piping and fittings. It is sized based both on how much graywater can be captured and by how much will be used by each fixture or outlet. The system must also, however, have the capacity to drain either immediately or after a period of storage into the sanitary drainage, rather than to fixtures and outlets.

This portion of the class will discuss how these design goals can be achieved.

Graywater Supply

Unlike potable water supply systems which are sized based on anticipated demand, graywater systems are sized by the amount of wastewater available for capture and reuse, with that sizing modified (i.e., limited) so as not to exceed demand, with provisions (where possible) for disposal of excess supply to the sanitary drainage system.

For residences, the amount of graywater-appropriate wastewater created obviously varies house to house. If the total usage of the house is known (from metering history), a rule of thumb would be to assume that about 60% of the water used inside the home would be considered graywater. The difficulty with this rule of thumb is it doesn't take into account outside water use, so may be best applied in an apartment or condominium.

To calculate available graywater supply, there are three general factors to consider:

1. Efficiency of the fixtures;
    - The average wastewater produced from showers using higher-flow shower heads (5 gpm) is 35 gallons; available wastewater from low-flow showers is 20 gallons.
2. Number of residents;

- The average person uses between 20 and 45 gallons per day for simple tasks such as bathing or showering, and using the washing machine.

3. Personal hygiene practices of the residents.

   - The average American showers every two to three days, with adults having higher frequency rates and children lower frequency rates.

Sample Procedure for Estimating Graywater Discharge

The number of occupants per dwelling should be calculated as:

First bedroom	2 persons
Each additional bedroom:	1 person

The estimated graywater flows per person is:

Showers, bathtubs, and washbasins	25 gpd
Laundry	15 gpd

Type of Washing Machine	Gallons Per Load of Wash
Traditional Top-Loading	35-50 gallons per load
Hi-Efficiency Top-Loading	15-25 gallons per load
Front-Loading	12-25 gallons per load

Multiply the total number of persons by the applicable estimated graywater discharge and type of fixtures connected to the graywater system.

Example: Single-family dwelling; three bedrooms with showers, bathtubs, washbasins; and laundry facilities all connected to the graywater system:

Total number of occupants = 2 + 1 + 1 = 4

Estimated graywater flow = 4x (25+15) = 160 gpd

Commercial Graywater Supply

For commercial buildings, estimates of graywater supply sources are harder to generalize and will vary widely. A typical estimate might be as follows:

1. Office building fixtures such as lavatories, water coolers, mop sinks, and coffee sinks are estimated to generate 1 gallon (3.79 liters) per person per day

2. The office building has approximately 500 employees

3. Anticipated available graywater is 500 gallons (1,893 L) per day.

4. Based on five working days per week and 50 working weeks per year, 125,000 gallons (473,177 Liters) per year could be available for graywater reuse.

Matching Demand and Supply

The most common uses of graywater are irrigation and flushing water for toilets and urinals. [Note: other uses, such as cooling tower makeup water, decorative pool and fountain fill water; power-washing, general floor and surface washing, vehicle washing, and laundry water supply often depend on treatment methods available; volumes are calculated based on flow/capacity of the treatment system and individualized need for each type of use].

Irrigation will be addressed in the next slide.

Toilet and Urinal use rates depend on the type of occupancy. For working adults, their toilet and urinal rate is 3-4 uses during the workday (with 75% of male uses being a urinal, if one is available). A working adult may have similar usage rates at home on work days, and the rates combined for non-workdays. Schooldays present similar calculating factors for the children affected.

Below, is a chart derived from LEED standards (version 4), as a helpful guide.

LEED v4 Baseline Calculations for Plumbing Fixtures	
Fixture	Baseline
Toilets	1.6 gpf (3.5 gpf for blowout closets)
Urinals	1.0 gpf
Lavatory faucets, private (see note*)	2.2 gpm at 60 psig
Lavatory faucets, public	0.5 gpm at 60 psig
Lavatory faucets, metering	0.25 gallons per cycle
Residential kitchen faucets	2.2 gpm at 60 psig
Showerheads	2.5 gpm at 80 psig
Pre-rinse spray valves	1.6 gpm (no psig specified)
Note*: Private lavatory faucets include both residential and private commercial applications such as hotel guest rooms and hospital patient rooms.	

Irrigation Systems

Graywater irrigation system design and selection begins with consideration of the following:

A. Water source (including the type of filtration/treatment available)

B. Soil type (and its interaction with the climate)

C. Type of plants/crops to be watered

D. Location & topology (including drainage characteristics)

E. Distance from adjacent properties, lakes, onsite water treatment, drainage channels, water supply lines, and wells

Water Source

When used for flushing, concern of the constituent elements of graywater is minimal. Indeed, graywater that contains high levels of chlorides, sodium, borax, and sulfates may have enhanced cleansing effect on fixtures.

When used for irrigation, however, whatever goes into the graywater will need to pass through whatever piping and outlets are involved, then go into the soil and be taken up by plants. The same high levels of chlorides, sodium, borax, and sulfates that are fine in toilets are poorly tolerated by some plants and, over time, the soil can increase in pH level. Topical fertilizers with high acidity such as ammonium sulfate can restore pH balance. High saline content can kill plants. One of the easiest strategies to reduce the sodium in the water is to choose soaps and detergents low in sodium-rich fillers (often added to soaps and detergents despite no enhanced cleaning effectiveness). Those with less filler (concentrated liquid detergents or natural soaps) usually have lower sodium content as compared to regular detergents. Other elements such as nitrogen and boron are plant food – beneficial at moderate levels but can cause problems at higher levels.

Soil Type

One way to look at graywater irrigation is that it is intended to water the ground, not the plant. The plant can partake once it's percolated into the ground, but it is the ground's capacity and permeability that is the critical design element. To calculate the required demand for an irrigation system, a soil analysis of the subsurface area must be performed. The chart, below, is an example of typical design criteria for the use of graywater systems for various soil types (coarse sand or gravel, fine sand, sandy loam, sandy clay, and mixed clay). As the soil weight decreases and the soil becomes less porous, the minimum square feet (square meters) needed for water absorption increases. For example, coarse sand or gravel needs a 20-square foot irrigation area per 100 gallons of estimated graywater discharge per day. Clay with a small amount of sand or gravel requires 120 square feet per 100 gallons of estimated graywater per day.

Design Criteria for Graywater Irrigation of Six Typical Soils	
Soil Type	**Irrigation Area per 100 Gallons of Estimated Graywater Discharge per Day, square feet**
Coarse sand or gravel	20
Fine sand	25
Sandy loam	40
Sandy clay	60
Clay with considerable sand or gravel	90
Clay w/ small amounts of sand or gravel	120

In addition to soil type, the moisture level of the soil should be considered. Overly dry soil will become hydrophobic (i.e., resist water), causing the graywater to run off. Overly wet soil will cause surface pooling. Capillary action has an effect as well – water moves slowly through dry soil, and relatively quickly through wet or moist soil. Because water bonds more tightly with other water molecules than to its environment, a moderately damp soil will allow the water the spread more widely across its expanse, increasing how much of the water will then be prone to gravity and be absorbed by the soil. The effect of gravity pulls the water down into the root zone and, if there's more water than the roots can take straight away, it keeps going down, into the subsoil.

A system designed to dispense graywater in smaller doses with higher frequency (at least daily) can have more centralized dispensers and have the water spread more evenly through damp soil and penetrate more readily without overwhelming the roots. After a few weeks of graywater irrigation on a daily or every second day basis, the top 3" to 6" of soil becomes uniformly moist, creating thousands of horizontal capillaries through which the water moves freely, rather than being absorbed unevenly into the subsoil. This allows for fewer irrigation lines per area to be watered and meets the standard of the simplest graywater system that meets the needs being the best.

Vegetation to be Watered

Depending on the season and the size of the distribution area, the amount of graywater generated per day may not be enough to satisfy the water requirements of the landscape. One strategy that graywater users should employ is to use several distribution areas. By directing the graywater to one area, the other areas can apply potable water, mitigating any harmful side-effects of graywater use.

As discussed earlier in this class, graywater should not come into contact with plants intended for consumption.

The owner of the property is responsible for deciding which plants to include in graywater irrigation areas. Numerous websites or state publications can provide guidance on which plants thrive in graywater and which do not. Signs of poor tolerance for the graywater include leaf burn, yellowing leaves, poor development of shoots or slowed overall growth, and the seeing the furthest extensions of branches (twigs) dying.

Location & Clearances Required

Graywater irrigation is not suitable for small garden plots. There has to be enough area for the water to infiltrate the soil without running off into adjoining areas. If a small garden is all that needs graywater, use of a bucket or bucket and hose to manually transport the graywater may be the best solution. Remember that one of the principles of graywater is that the simplest solution that meets all needs is almost always best.

Even when there is suitable square footage to justify a graywater irrigation system, distances between graywater system components or from graywater irrigated soil to any element that needs to be protected against contamination must be maintained (see chart, below, for some examples)

Laundry to Landscape

Another means to provide graywater for a smaller garden or for trees and shrubs is to only harvest water from the washing machine. This arrangement involves the least amount of dislocation to an existing plumbing system, since washing machines already drain into a relatively accessible hose. That being said, this should NEVER be accomplished by direct connection from the drainage hose behind the washing machine to the garden and lawn, for the following reasons:

1. Unless the user only uses cold water wash and rinse, the delivery of hot or even warm water could damage or kill plants;

2. Washing machines typically expel the water under pressurized conditions; unless the connections to foliage is gravity-based and protected against kinks and clogs, the pump could be stressed and burn out prematurely;

3. Washing machines typically drain into a standpipe, which prevents siphonage. Unless protected against siphonage, direct-connection tubing could exert pressure on the water in the tank when it's filling and draw water from the tank even though it's not in the spin cycle, destroying the rationale for a graywater connection and interfering with the washing machine's operation; and

4. Standing water in the line can back up into the washing machine under some circumstances, such as lifting the irrigation lines to reposition them.

In order to avoid these problems, a laundry-to-landscape system is most often connected through a diverter valve, which is vented when open to landscape to prevent siphoning. The diverter valve allows the user to have the machine continue to drain to the normal sanitary drainage system if it isn't cool or cold and then switch the flow of graywater to the irrigation system when appropriate. The laundry diverter valve is usually mounted on the wall behind the washer or where it is easily visible and convenient to turn.

Venting helps prevent siphoning, but since the irrigation is likely below the water level in the washing machine, a vacuum breaker in the drain line can provide more reliable protection.

In addition, an overflow that empties harmlessly may be required if the system for any reason fails to drain at its outlet. If the line freezes, for example, a pipe through which the water rises and harmlessly overflows can prevent the pump from burning out or water returning into the machine when the line clogs with ice.

The preferred distribution plumbing for laundry-to-landscape systems is 1" PE tubing with a purple stripe to indicate non-potable water. Smaller tubing gives too much resistance while bigger tubing traps more septic water and crud and is a waste of plastic. Washing machine graywater should be gravity irrigated when the washing machine is not in a basement. Outlet branches can be 1", ¾", or ½" and can run under or over mulch (mulch allows for predictable percolation where direct watering can percolate more or less rapidly under differing conditions). The capacity of all the outlets should be large enough so that the pump is not strained by trying to push too much water through too small tubes. If relying on the pump to push the water to a higher elevation, it's best to have all the water pumped directly to the highest elevation, then drain through gravity to the outlets below.

The washing machine pump is not designed be used to pressurize an irrigation system. Using a 55-gallon surge tank with a separate pump to run the irrigation system is preferable.

Additional recommendations on installing these systems can be found in the San Francisco Graywater Design Manual.

[SLIDECUT]

[QUESTIONHEADER]

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When calculating how much graywater would be required to serve a male restroom with urinals, what percentage should be assumed for	75% urinal, 25% water closets	50% urinal, 50% water closets	90% urinal, 10% water closets	65% urinal, 35% water closets

urinal use compared to water closets?				

[QUESTIONBOTTOM]

[SLIDECUT]

Best Practices and Codes for Graywater Systems

Best Sources

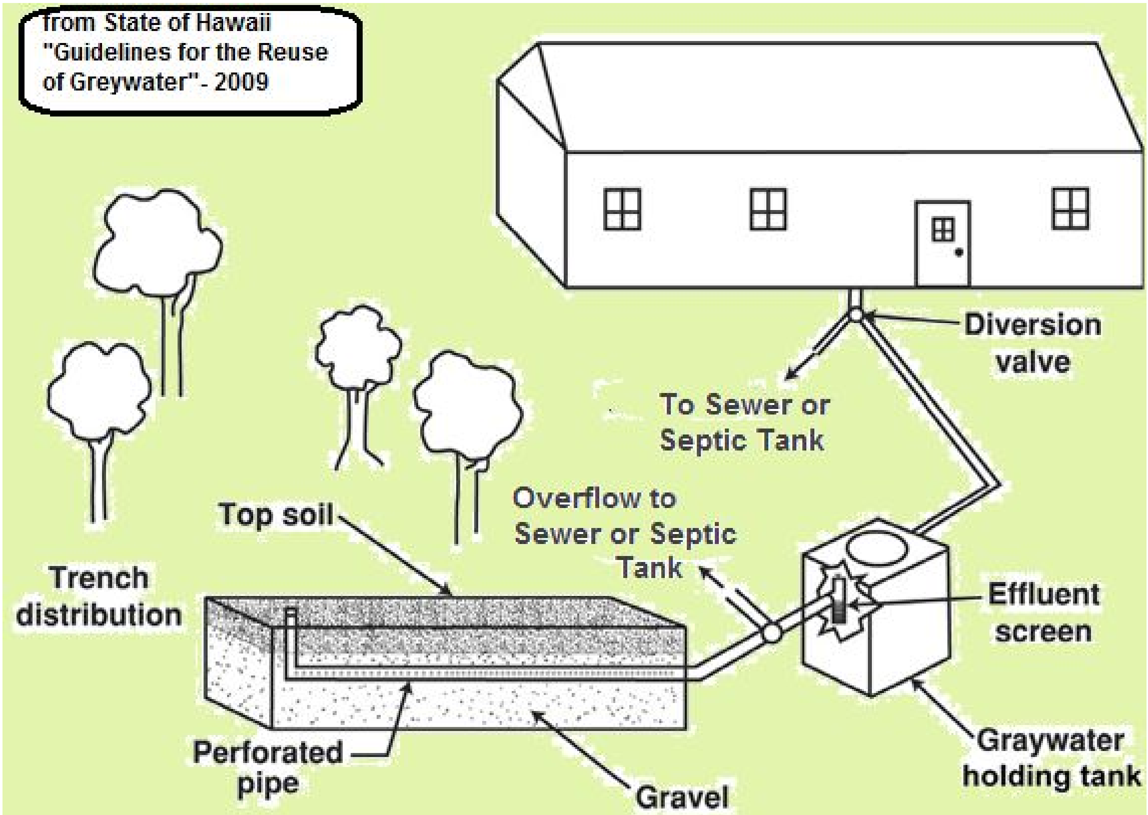
Codes allow acquisition of graywater from bathtubs, showers, lavatories, clothes washers, and laundry tubs. Judgment on which sources to actually use depends on how the structure is configured as well as whether it uses municipal sewers or an onsite septic system.

- Where municipal sewers are available, it usually makes sense to only harvest from the largest available sources – first the shower/bath, then the washing machine. Although lavatories are permitted, the available supply is relatively small and may not justify the expense and complexity. If there is a laundry tray, it may or may not yield enough to justify connection.
- Where served by a septic system, it makes more sense to connect lavatories, as well as determining if a grease interceptor or separator between the kitchen sink drain and the graywater system can provide sufficiently clear graywater.
- Dishwasher detergent is caustic, so that even if connected through a grease interceptor, its utility as graywater is limited.

Recommended Installation Elements

Graywater contains organic matter and, if stored, it will quickly turn septic, generate offensive odors, and promote the growth of pathogenic microorganisms. It's critical to size the graywater holding tank appropriately so that it does not hold graywater for longer than 24 hours and to have it empty to the sanitary drainage system when held for any longer period. Some tanks have an automatic draining timer release valve. Generally, a 55-gallon tank should be sufficient but, in no case, should it be designed to hold more than one day's production volume.

When used for irrigation, an effluent screen should be placed in the outlet piping to collect debris that might otherwise exit the holding tank with the discharged graywater and clog irrigation piping. Irrigation distribution piping should be below the soil surface to minimize potential health risks and odor. Distribution of graywater using a spray irrigation system is prohibited and edible root crops should not be irrigated with graywater. Graywater is best used for more water-intensive vegetation and is meant for well-established plants rather than for seedlings. To prevent salt accumulation, distribute graywater over a large surface area and rotate distribution from one area to another.



The Hawaii Department of Health graywater guide includes an example (shown above) of a subsurface distribution system that includes graywater dosed to a gravel bed or trench underlying a flowerbed; water not taken up by plants then percolates through the soil profile. Gravity-based irrigation distribution lines, built from standard poly tube or branched drain networks, are difficult to design for even irrigation. Graywater systems equipped with pumps can more evenly disperse water through a pressurized subsurface drip system to irrigate trees, gardens, and planter boxes. Pressurized (pumped) graywater dripper-line systems require only small pumping cisterns to irrigate as many as 7,000 square feet, and are able to pump graywater as much as 25 feet uphill and an unlimited distance downhill without the need for a secondary pump.

Rarely do graywater systems require piping of similar diameter to other types of drainage piping, which is often 3 to 4 inches. Pipe that is over-sized is more awkward, expensive, requires greater slope, and moves more slowly, resulting in more deposits of sediment. Piping of 1½ to 2-inch diameter is sufficient.

Distribution piping, on the other hand, in the irrigation trenches should avoid small perforations and may need to be of a larger diameter than if designed for potable water to avoid fouling. Traditional designs use gravel or small rocks to support distribution irrigation lines. Wood chips are an alternative that provide superior drainage and avoid build-up of grit and sludge. They also decompose so they need to be replenished periodically.

Recommended Maintenance Protocols

To keep graywater systems working properly, all treatment and reuse systems require some level of attention to their operation and maintenance. Never install a graywater system without providing the users with a manual on how to avoid problems and how to perform routine maintenance. Some typical maintenance protocols would include the following:

- Clean the effluent screen at least annually. Remove the screen and spray residuals off into a large bucket. The residuals and wash-water collected in the bucket should be handled and processed as blackwater.
- Remove accumulated solids from the holding 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 at all times. During rainy seasons, winter, or other periods of time when it is not used, set the diversion valve to direct flow to the sanitary drainage.
- If the graywater system is pressurized, periodic maintenance and replacement is necessary.
- The end caps of the irrigation lines should be removable to allow periodic cleaning and removal of built-up solids.

Codes

2015 IPC® Section 1302 On-Site Nonpotable Water Reuse Systems

As an example of recent model codes on graywater systems, the following is a selection of code from Section 1302 of the 2015 IPC® (On-Site Nonpotable Water Reuse Systems):

> **2015 IPC® 1302.2 Sources.** On-site nonpotable water reuse systems shall collect waste discharge from only the following sources: bathtubs, showers, lavatories, clothes washers and laundry trays. Water from other *approved* nonpotable sources including swimming pool backwash operations, air conditioner condensate, rainwater, cooling tower blowdown water, foundation drain water, steam system condensate, fluid cooler discharge water, food steamer discharge water, combination oven discharge water, industrial process water and fire pump test water shall also be permitted to be collected for reuse by on-site nonpotable water reuse systems, as *approved* by the code official and as appropriate for the intended application.

1302.2.1 Prohibited Sources. Wastewater containing urine or fecal matter shall not be diverted to on-site nonpotable water reuse systems and shall discharge to the sanitary drainage system of the building or premises in accordance with Chapter 7. Reverse osmosis system reject water, water softener discharge water, kitchen sink waste water, dishwasher waste water and waste water discharged from wet-hood scrubbers shall not be collected for reuse in an on-site nonpotable water reuse system.

2015 IPC® 1302.4 Collection Pipe. On-site nonpotable water reuse systems shall utilize drainage piping *approved* for use in plumbing drainage systems to collect and convey untreated water for reuse. Vent piping *approved* for use in plumbing venting systems shall be utilized for vents in the gray water system. Collection and vent piping materials shall comply with Section 702.

1302.4.2 Joints. Collection piping conveying untreated water for reuse shall utilize joints *approved* for use with the distribution piping and appropriate for the intended applications as specified in Section 705.

1302.4.3 Size. Collection piping conveying untreated water for reuse shall be sized in accordance with drainage sizing requirements specified in Section 710.

1302.4.4 Labeling and Marking. Additional marking of collection piping conveying untreated water for reuse shall not be required beyond that required for sanitary drainage, waste and vent piping by Chapter 7.

1302.5 Filtration. Untreated water collected for reuse shall be filtered as required for the intended end use. Filters shall be accessible for inspection and maintenance. Filters shall utilize a pressure gauge or other *approved* method to provide indication when a filter requires servicing or replacement. Filters shall be installed with shutoff valves immediately upstream and downstream to allow for isolation during maintenance.

1302.6 Disinfection and Treatment. Where the intended application for nonpotable water collected on site for reuse requires disinfection or other treatment or both, it shall be disinfected as needed to ensure that the required water quality is delivered at the point of use. Nonpotable water collected on site containing untreated gray water shall be retained in collection reservoirs for a maximum of 24 hours.

1302.6.1 Gray Water Used for Fixture Flushing. Gray water used for flushing water closets and urinals shall be disinfected and treated by an on-site water reuse treatment system complying with NSF 350.

1302.7 Storage Tanks. Storage tanks utilized in on-site nonpotable water reuse systems shall comply with Sections 1301.9 and 1302.7.1 through 1302.7.3.

1302.7.1 Location. Storage tanks shall be located with a minimum horizontal distance between various elements as indicated in Table 1302.7.1.

TABLE 1302.7.1 LOCATION OF NONPOTABLE WATER REUSE STORAGE TANKS	
ELEMENT	**MINIMUM HORIZONTAL DISTANCE FROM STORAGE TANK (feet)**
Critical root zone (CRZ) of protected trees	2
Lot line adjoining private lots	5
Seepage pits	5
Septic tanks	5
Water wells	50
Streams and lakes	50
Water service	5
Public water main	10
For SI: 1 foot = 304.8 mm.	

2015 IPC® 1302.7.3 Outlets. Outlets shall be located not less than 4 inches (102 mm) above the bottom of the storage tank and shall not skim water from the surface.

1302.8.1 Bypass Valve. One three-way diverter valve listed and labeled to NSF 50 or other approved device shall be installed on collection piping upstream of each storage tank, or drainfield, as applicable, to divert untreated on-site reuse sources to the sanitary *sewer* to allow servicing and inspection of the system. Bypass valves shall be installed downstream of fixture traps and vent connections. Bypass valves shall be marked to indicate the direction of flow, connection and storage tank or drainfield connection. Bypass valves shall be installed in accessible locations. Two shutoff valves shall not be installed to serve as a bypass valve.

1302.8.2 Backwater Valve. One or more backwater valves shall be installed on each overflow and tank drain pipe. Backwater valves shall be in accordance with Section 715.

1302.9 Pumping and Control System. Mechanical equipment including pumps, valves and filters shall be easily accessible and removable in order to perform repair, maintenance and cleaning. The minimum flow rate and flow pressure delivered by the pumping system shall be appropriate for the application and in accordance with Section 604.

1302.10 Water Pressure-Reducing Valve or Regulator. Where the water pressure supplied by the pumping system exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the nonpotable water distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section 604.8.

1302.11 Distribution Pipe. Distribution piping utilized in on-site nonpotable water reuse systems shall comply with Sections 1302.11.1 through 1302.11.3.

Exception: Irrigation piping located outside of the building and downstream of a backflow preventer.

2015 IPC® 1302.13 Operation and Maintenance Manuals. Operation and maintenance materials shall be supplied with nonpotable on-site water reuse systems in accordance with Sections 1302.13.1 through 1302.13.4.

1302.13.1 Manual. A detailed operations and maintenance manual shall be supplied in hard-copy form with all systems.

1302.13.2 Schematics. The manual shall include a detailed system schematic, and the locations and a list of all system components, including manufacturer and model number.

1302.13.3 Maintenance Procedures. The manual shall provide a schedule and procedures for all system components requiring periodic maintenance. Consumable parts, including filters, shall be noted along with part numbers.

1302.13.4 Operations Procedures. The manual shall include system startup and shutdown procedures. The manual shall include detailed operating procedures for the system.

2015 UPC® Chapter 15 Alternate Water Sources for Nonpotable Applications, Part 1

In order to provide a brief overview of how the 2015 edition of the Uniform Plumbing Code® sets out provisions and requirements for graywater systems, the next four slides will contain the full Section 1502 (Gray Water Systems)

2015 UPC® Chapter 15 Alternate Water Sources for Nonpotable Applications, Part 2

You might notice that the provisions, below, include rules for calculating available graywater that match, perfectly, the rules presented earlier in this lesson.

2015 UPC® Chapter 15 Alternate Water Sources for Nonpotable Applications, Part 3

2015 UPC® Chapter 15 Alternate Water Sources for Nonpotable Applications, Part 4

This final set of provisions from the 2015 UPC® continues Section 1502.9 (Gray Water System Components) then finishes with codes on subsurface irrigation.

2015 UPC® 1502.9.3 Subsoil Irrigation Field Materials. Subsoil irrigation field piping shall be constructed of perforated high-density polyethylene pipe, perforated ABS pipe, perforated PVC pipe. or other approved materials'. provided that sufficient openings are available for distribution of the gray water into the trench area. Material, construction, and perforation of the pipe shall be in accordance with the appropriate absorption field drainage piping standards and shall be approved by the Authority Having Jurisdiction.

1502.9.4 Subsurface Irrigation Field and Mulch Basin Supply Line Materials. Materials for gray water piping outside the building shall be polyethylene or PVC Drip feeder lines shall be PVC or polyethylene tubing.

1502.9.5 Valves. Valves shall be accessible.

1502.9.6 Trap. Gray water piping discharging into the surge tank or having a direct connection to the sanitary drain or sewer piping shall be downstream of an approved water seal type trap(s). Where no such trap(s) exists, an approved vented running trap shall be installed upstream of the connection to protect the building from possible waste or sewer gases.

1502.9.7 Backwater Valve. A backwater valve shall be installed on gray water drain connections to the sanitary drain or sewer.

1502.10 Subsurface Irrigation System Zones. Irrigation or disposal fields shall be permitted to have one or more valved zones. Each zone shall be of a size to receive the gray water anticipated ill that zone,

1502.10.1 Required Area of Subsurface Irrigation Fields. Subsoil Irrigation Fields and Mulch Basins. The minimum effective irrigation area of subsurface irrigation fields, subsoil irrigation fields, and mulch basins shall be determined by Table 1502.10 for the type of soil found in the excavation, based upon a calculation of estimated gray water discharge pursuant to Section 1502.8. For a subsoil irrigation field, the area shall be equal to the aggregate length of the perforated pipe sections within the valved zone multiplied by the width of the proposed subsoil irrigation field.

1502.10.2 Determination of Maximum Absorption Capacity. The irrigation field and mulch basin size shall be based on the maximum absorption capacity of the soil and determined using Table 1502.10. For soils not listed in Table 1502,10. the maximum absorption capacity for the proposed site shall be determined by percolation tests or other method acceptable to the Authority Having Jurisdiction. A gray water system shall not be permitted where the percolation test shows the absorption capacity of the soil is unable to accommodate the maximum discharge of the proposed gray water irrigation system.

1502.10.3 Groundwater Level. No excavation for an irrigation field, disposal field. or mulch basin shall extend within 3 feet (914 mm) vertical of the highest known seasonal groundwater level, nor to a depth where gray water contaminates the groundwater or surface water. The applicant shall supply evidence of groundwater depth to the satisfaction of the Authority Having Jurisdiction

[SLIDECUT]

[QUESTIONHEADER]

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2015 UPC Section 1502.10-3 prohibits excavation for graywater irrigation or mulch basins within the following distance from seasonal groundwater levels:	Three feet	Six feet	Five feet	Eight feet

[QUESTIONBOTTOM]

[SLIDECUT]

[VIDEOHEADER]

POWTS (Video)

All methods of sewage disposal are essentially a bridge created so that water, after being used in homes and businesses, can be reinserted back into the hydrologic cycle. When this use includes human wastes, contaminated water of undesirable quality is transported by this system and, after processing or treatment of some kind, returned at an acceptable level of quality to the soil and ultimately to the water table. Whatever does not evaporate and return as precipitation is then available for absorption by plants, followed by transpiration as water vapor from the plants, so that it, too, can return as precipitation and complete the cycle.

There are two basic types of privately-owned sewage disposal systems – cesspools and septic tank/soil absorption systems. The cesspool is an antiquated technology and not permitted as new installations. On the other hand, privately-owned and operated septic tanks and absorption fields are relied on by about one quarter of American homes, mainly in rural areas, but one city, at least – Indianapolis – relies heavily on them. When properly used and maintained, they've been shown to be as effective and safe as municipal sewage treatment facilities, more energy-efficient, and – in some cases – less expensive.

As a working plumber, these systems may be part of your practice but, even if you don't handle them directly, some of the sanitary drainage plumbing you work on is sure to empty into one or another of these systems. It's useful to have a working knowledge of how they work and what's involved in proper design and installation.

There are three key steps in these systems:

1. Primary treatment;
2. Dispersal through drainfields or seepage pits, where pre-treated effluent is filtered and bacteria dies out; and
3. Removal of byproducts through the venting of gas and removal of non-organic wastes and sludge.

Primary treatment is either aerobic and anaerobic. Both use bacteria to decompose organic matter and separate other solids from received sanitary drainage. Both produce a liquid effluent from the decomposed solid wastes mixed with other drainage components which they then pass on for soil absorption.

This class will only cover anaerobic treatment systems. Although aerobic bacterial treatment has some advantages and is widely used at municipal facilities, it is far more complicated and rare in private systems. I should mention that, although anaerobic means “without oxygen”, that’s not entirely accurate. True anaerobic conditions require pressurized tanks; which private septic tanks are not. The reason they have this name is that – unlike aerobic treatment – no oxygen is injected or mixed into the effluent and, unlike the single bacterial cultures of aerobic systems, numerous bacteria thrive in anaerobic systems, making it far more appropriate to private septic tanks.

The class will begin with a brief look at history, development, and basic principles, followed by a survey of laws and regulations that typically apply. We’ll touch on some key design considerations, then cover septic tanks and soil absorption fields, seepage pits and alternative technologies, and finish by looking at larger commercial or institutional systems.

[VIDEOBOTTOM]

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[QUESTIONHEADER]

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Which of the following best characterizes anaerobic bacterial treatment in POWTS?	Oxygen is not injected or mixed into the effluent and numerous bacteria are active	Tanks are pressurized so that only a selected bacterial culture can thrive, which can then process the effluent	Oxygen is removed from the effluent through adsorption so that the bacteria die as they process organic wastes, emitting high	Turbulence in the tank caused by the continual injection of the effluent stream results in increased oxygen load, fostering more rapid

			quantities of methane	decomposition of organic wastes

[QUESTIONBOTTOM]

[SLIDECUT]

Private Onsite Wastewater Treatment Systems

History

Cesspools were introduced in the early days of the Renaissance in Europe (late 1400s) to replace the discharging of “slop pots” into streets and public areas. Their technology is largely unchanged to the present day. A cesspool is an underground tank with holes in the side and/or bottom through which wastewater is discharged into the surrounding soil. In other words, a cesspool discharges raw sewage through its perforated walls into the environment. The problem with traditional cesspools is that sewage is discharged into a small diameter pit, which causes the wastewater to disperse under saturated, anaerobic conditions, limiting soil treatment. The small size of these systems also increases the likelihood of sewage back-up into the dwelling and surfacing sewage. There is also a safety concern with many of these systems because the tank lids may collapse, resulting in an unsafe environment for people, animals, and infrastructure. The solids (sludge) that are retained in the pit are malodorous and require frequent pumping by disposal services, especially as the raw sewage increasingly clogs the perforations in the pit lining. Typically, once the perforations are permanently clogged, the cesspool is abandoned and a new one constructed.

[Note: A seepage pit (discussed later in this class) should never be confused with a cesspool. Although their construction is similar, a seepage pit receives the effluent from a septic tank (where the solids have been liquefied), while a cesspool receives raw sewage.]

The U.S. relied almost exclusively on cesspools or similar constructions until widespread construction of sewer systems accompanied urban growth from 1850 to 1900. The first federal program to encourage treatment, rather than simple dispersal of sewer flows, was passed in 1912 but it wasn't until 1972's Clean Water Act that modern treatment methods became mandatory. Where sewer lines did not reach, cesspools still predominated and continued to release barely treated sewage into the environment. Making this even worse, many cesspools in the U.S. were intentionally sited with the bottom in groundwater to take advantage of the natural water movement to carry the sewage away. Raw or partially treated sewage should never reach groundwater. The presence of improperly treated sewage is a threat to public health and ecological balance. Human exposure to sewage has resulted in disease outbreaks, severe illnesses, and in some instances death from the bacteria, viruses, and parasites contained in the waste.

Development of Private On-Site Water Treatment Systems (POWTS)

The solution many communities found was centralized wastewater treatment. From the end of World War II to the present, the number of municipal wastewater treatment plants increased from a few hundred to 16,000. Unfortunately, much of the U.S. is poorly suited to the traditional sanitary engineering approach of building a network of sewers to convey wastewater to a central location for treatment and disposal to surface waters. Having few users per unit length of sewer line in low-density settings means the cost of construction and operation on each user is high. For years, this expense was partially offset by federal grants covering as much as 90% of the costs of construction for sewers and centralized treatment plants, which left behind high operating and maintenance costs for communities.

The development of Private On-Site Water Treatment Systems (POWTS) has provided an alternative. The cost of a centralized sewer tie-in (including fees and cost of the sewer lateral) can easily rise to $30,000 or more per home, mainly in rural areas but also in outlying areas of suburbs that are increasingly spreading into the countryside. In contrast, the cost of septic system installation ranges from $1,500 to $15,000, with an average cost just above $3000. With proper maintenance (including having the tank pumped regularly, conserving water, managing solids in wastewater, keeping potentially hazardous materials out of wastewater, not using additives, and protecting the drainfield), the systems should last for decades.

Wherever sanitary sewers are not available, it becomes necessary for the plumbing engineer to design private sewage systems to handle the wastes. There are two types of privately owned systems – cesspools and septic tank/soil absorption systems. Cesspools are low-tech, require minimal space, but they are not safe or practical and they are no longer permissible.

POWTS, in contrast, require a minimum of two-to-three vertical feet of dry, well-aerated soil with a wastewater primary treatment and disbursement design sized on the basis of the kind of uses (e.g. single family home, day care facility, etc.) and soil properties. The goal is to effectively remove solids, nutrients, bacteria, and viruses from the wastewater and allow for safe integration of the treated waste into the natural environment.

Because these systems are intended to introduce water back into the Earth, the regulatory authorities will usually be environmental protection agencies (both state and federal), as well as local health and water departments. Different states and regulatory agencies apply a variety of names for these systems – from sanitary system disposal (SSD) to individual sewage treatment systems (ISTS). For this class, the term we'll use is Private Onsite Wastewater Treatment System (POWTS). It's been adopted by a majority of states as well as by ASPE and several national membership organizations that provide resources for design and construction of POWTS.

Principles

Improper or inadequate disposal of sewage fosters a rapid and virulent spread of intestinal disorders, diarrhea, and nausea, as well as more serious diseases such as dysentery, infectious hepatitis, typhoid, paratyphoid, and cholera.

Any person or entity involved in disposal of sewage has the public's health in his or her care. Improper handling or release can have devastating consequences. On behalf of the public, therefore, the design, use, and maintenance of POWTS is strictly regulated. Most areas of the country have local regulations that must be followed regarding the design of sewage treatment and dispersal systems. The following goals must be met:

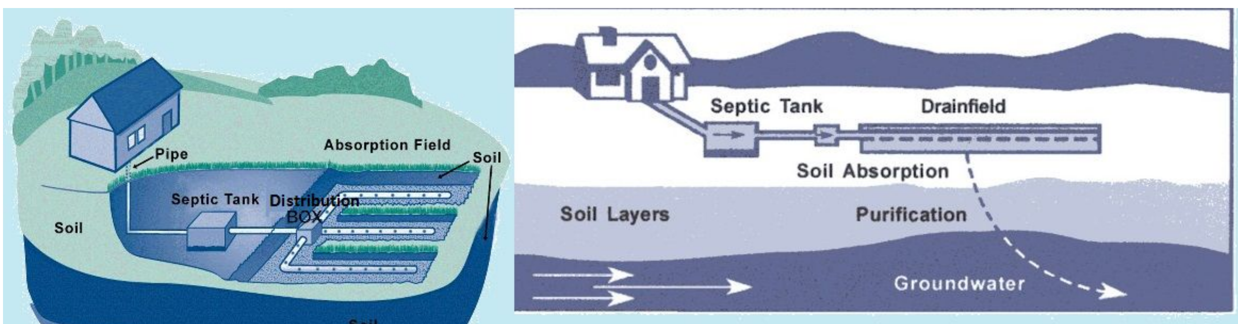
1. It must not contaminate any drinking water supply;
2. It must not be hospitable to insects, rodents, or other possible disease carriers;
3. It must not be accessible to children;
4. It must not violate laws or rules and regulations governing water pollution or sewage disposal;

5. It must not pollute or contaminate the waters of any bathing beach, shellfish breeding ground, or any stream used for public or private water supply or for recreational purposes; and

6. It must not become malodorous or unsightly in appearance.

In addition to being responsible for construction and maintenance, the owner/operator of a POWTS is responsible for its proper use. In particular, the wastewater discharge to POWTS must be controlled. These systems are not designed to handle solids, such as disposable diapers, feminine products, food disposal wastes, or excessive oils, fats, and greases. Either the introduction of these products and substances must be prevented from entering or removed by an appropriate interceptor before reaching the septic tank. Additionally, the overall flow of sanitary drainage must be controlled to stay within operational limits for the system.

Basic Design



Images courtesy City of Eau Claire, WI and Boston University

The most common POWTS is a septic tank in combination with a traditional drainfield. In a septic tank/drainfield system, wastewater flows from the household plumbing into an underground septic tank. There, waste components naturally separate, with heavier solids settling to the bottom, forming sludge, and lighter solids floating to the top, forming scum). Bacteria begin to treat wastewater by partially decomposing the solids. *[Note: Decomposition of the sewage under anaerobic conditions is termed "septic"; it's from this that the tank derives its name.]* The liquid (effluent) flows that results from this bacterial decomposition in solution with other wastewater flows through the tank outlet and through laterals to the subsurface drainfield, also called a soil absorption field or leach field laterals. A system may have a distribution box between the septic tank and the drainfield to distribute effluent evenly between multiple drainfield trenches.

The drainfield usually consists of a series of underground parallel trenches. Each trench may contain a distribution pipe embedded in gravel or rock, or may have chambers without any gravel. The effluent flows through the distribution pipes or chambers where it moves through holes in the pipe or chambers down into the soil. The draining water slowly moves down through the soil, eventually reaching groundwater. The soil filters out remaining small solids and pathogens (disease-causing microorganisms). At the same time, bacteria and other microorganisms in the soil treat pathogens and other contaminants in the effluent.

[Note: A distribution box is not recommended unless the POWTS serves a larger structure or otherwise has a larger load than a single-family home. It's far better so simply have each trench drain to its neighbor if it becomes saturated, which (on relatively level ground) is a natural way to evenly distribute that is superior to adding a box that can befoul or interfere with efficient operation. A distribution box won't overcome sloping, if that's an issue, since distribution to a higher trench will flow toward the lower trenches, anyway.]

A POWTS must be designed to accommodate the anticipated quantities of wastewater that will be discharged into the system. The septic tank must be large enough to maintain its anticipated load of effluent for at least 24 hours or the time sufficient to reduce the contaminant load and separate out the types, quantities, and concentrations of wastewater contaminants suitable to the discharge conditions. The resulting effluent outflow must discharge below the surface of the ground at a rate that promotes long-term assimilation into the soil and limits the possibility of surfacing, so that the dispersed wastewater will not create a human health hazard. Typically, a permit application will need to address the following:

- The flow and contaminant load of the influent wastewater;
- The flow velocities and friction losses throughout the system based upon accepted engineering practice;
- The ability of all treatment and dispersal components to reduce contaminant load and disperse hydraulic flow into the environment; and
- The area of soil and soil characteristics and anticipated rate of absorption and passage to groundwater.

Flow Velocity

image by AYPO

In order to provide adequate flow to maintain the system with either a gravity-based or pump-based (pressurized) installation:

- Either –
  - Gravity flow piping between POWTS components must be installed at a pitch that produces a computed flow velocity of at least 1 foot per second when flowing half full; or
  - Pressurized systems must produce a computed velocity of at least 2 feet per second.
- Gravity piping within a POWTS treatment or dispersal component consisting in part of in situ soil shall be installed level or pitched downstream a maximum 4” per 100’.
- The piping within a POWTS shall be of a diameter to permit the operation of the POWTS.
- The orientation of a POWTS treatment or dispersal component consisting in part of in situ soil shall take into account landscape variations in elevation, slope orientation, and other conditions that could affect component performance relative to dispersal or aeration.

Gravity vs. Pump-Based Collection and Distribution

As with all plumbing installations, gravity based systems are always best. Sizing and slope from the building drain to the septic tank are the same as for any drainage system. If the septic tank receives effluent other than raw wastes, smaller-diameter pipe may be used to reduce the cost of conventional gravity sewers. Four-inch (101.6-millimeter) mains should be installed at a minimum gradient of 0.67 percent based on a minimum velocity of 1.5 feet per second (0.5 meter per second) at half-pipe flow capacity.

If conditions don’t allow a gravity-based system, a pressure-based system with smaller septic tanks located closer to the structure it serves is often preferable to a larger shared tank. A smaller tank with smaller diameter pipes can retain pressure with a relatively small submersible pump.

Vacuum transport systems consist of a vacuum pump, a receiving tank (held at approximately 7.5 pounds per square inch absolute (psia), and a vacuum valve. When there is sufficient sewage in the lateral and the vacuum is at the proper level, the valve will open, and the sewage will enter as a slug. The slug of wastewater will move toward the receiving tank until the dispersal of the slug results in a break in the seal, thus ending the vacuum effect. Traps should be placed at regular intervals in the mains to reshape the slugs. When the trap fills, the vacuum effect is reestablished, causing the slug to continue toward the receiving tank with the next operation of the valve. Vacuum sewers flow full and provide many of the advantages of pressure sewers.

Similar to the plumbing installed to move effluent from the building drain to the septic tank the soil absorption system receives the effluent from the primary treatment tank by means of gravity directly to the trenches or a pump system to a distribution box.

Sizing – Estimating Wastewater Flow

The first determination to be made is the volume of sewage the system will need to handle.

- If the system is to be installed in a structure already occupied or operating for its intended use, the most accurate metric is simply to obtain water meter readings. If receiving municipal water supply, either the owner can provide several months of water bills or the utility can provide those numbers. The full amount should be reduced by any amount used outside the structure (such as for irrigation) which would then not flow into sanitary drainage. Whatever total is derived, a safety factor should be calculated, so that the system is designed to accommodate 110% or more of anticipated flow. Most municipalities will require that capacity be equal to 150% of the anticipated flow, to take peak periods into account. Remember, local codes are always determinative, although they are likely to overestimate needed volume.

- Where local codes don't apply and water meter readings are unavailable or irrelevant, it's necessary to use other methods of estimating the amount of sewage to be discharged. ASPE has developed a Chart (see below) that provides an estimate of average daily wastewater flows for residential facilities, including minimum and maximum flow and frequency distribution. This data may be particularly useful for apartments, mobile home parks, and similar residential facilities that are still under construction.

		Flow, gal (L) per unit, per day	
Source	**Unit**	**Range**	**Typical**
Apartment	Person	53–90(200–340)	69(260)
Hotel, residential	Resident	40–58(150–220)	50(190)
Individual Dwelling			
Average home	Person	50–92(190–350)	74(280)
Larger-than-Average home	Person	66–106(250–400)	82(310)
Luxury home	Person	79–145(300–550)	100(380)
Semi-modern home	Person	26–66(100–250)	53(200)
Trailer park	Person	32–53(120–200)	40(150)

This ballpark use of the ASPE chart may be too imprecise. For more site-specific calculation, of residential sewerage volume, the most widely accepted method for residences is to base the estimated flow on the number of bedrooms. A second, more complex, method is to calculate the flow on the basis of the number and kinds of plumbing fixtures. A sample codification of these methods, from Wisconsin, is shown below:

Estimated Daily Combined Flow for a POWTS Serving a Dwelling

The estimated daily wastewater flow of combined graywater, clear water, and blackwater from a dwelling shall be based on one or more of the following:

(a) The equation: 100 gallons x B = F

Where: B = number of bedrooms, based on 2 persons per bedroom, unless otherwise approved by the department. F = Estimated daily wastewater flow per dwelling per day (in gallons), excluding storm water discharges.

[Note: Wisconsin codes provides an equation for graywater, alone, as 60 gallons x B = F, and an equation for blackwater, alone, as 40 gallons x B = F.]

(b) A detailed estimate of wastewater flow based upon per capita occupancy or usage of the dwelling or per function occurrence within the dwelling.

Estimating for Commercial Facilities

If metering data is unavailable or irrelevant, estimations for commercial occupancies is harder to calculate. For example, if the building is used as a restaurant, the number of meals served may be the best criteria. The codification of this calculation from Wisconsin reads as follows:

Estimating Wastewater Flow for Commercial Facilities

This shall be based on either:

(a) The measured daily wastewater flow over a period of time representative of the facility's use or occupancy; or

(b) A detailed estimate of wastewater flow based upon per capita occupancy or usage of the facility or per function occurrence within the facility.

Estimating Contaminant Loads

Permit applications for POWTS may require submission of testing results for fats, oils, grease, total suspended solids, and biochemical oxygen or other contaminants typical of the effluent to be handled by the POWTS. A chart, below, shows how some of these testing results may be calculated.

Disposal Field

Once you've determined the expected flow, you might expect that the next step is to select a septic tank. In fact, the next step is NOT to size a septic tank, but to assess whether a suitable and adequate disposal field is available. Dispersal is affected by:

1. The depth of the unsaturated receiving soil;
2. The soil's hydraulic conductivity;
3. Influent application rate;
4. Topography and slope;
5. Surface water, and the seasonal high-water table
    - The maximum elevation of the groundwater table should be at least four feet below the bottom of the trench or seepage pit. Rock formation or other impervious strata should be at a depth of more than four feet below the bottom of the trench or seepage pit; and
6. The area available for dispersal, taking into account minimum setbacks from surface waters, wells, and property lines as mandated by local codes.

Many of these design factors can be determined by running a "percolation test".

The percolation rate should be within the range shown in Table 21-5 or Table 21-6.

A chart from ASPE used to determine how large the drainage field must be based on differing percolation test results

Absorption Area Requirements for Individual Residences[a]	
Percolation Rate (time required for water to fall 1 in.), in minutes	Required Absorption Area, in ft^2/bedroom[b], standard trench[c], seepage beds[c], and seepage pits[d]
1 or less	70
2	85
3	100
4	115
5	125
10	165
15	190
30[c, e]	250
45[c, e]	300
60[c, e, f]	330

a It is desirable to provide sufficient land area for an entire new absorption system if needed in the future.
b In every case, sufficient land area should be provided for the number of bedrooms (minimum of two) that can be reasonably anticipated, including the unfinished space available for conversion as additional bedrooms.
c Absorption area is figured as trench bottom area and includes a statistical allowance for vertical side wall area.
d Absorption area for seepage pits is figured as effective side wall area beneath the inlet.
e Unsuitable for seepage pits if over 30.
f Unsuitable for absorption systems if over 60

Role of the Septic Tank

The role of the septic tank is to partially treat the wastewater by decomposition of the larger particles, while permitting sand and grit time to settle. In order to accomplish this, a septic tank is a liquid-tight structure, with inlet and outlet connections, designed to retain raw sewage for a specified period of time, usually 24 hours.

There are three tasks a septic tank must be designed to perform:

1. Removal of solids [settling];
2. Biological treatment; and
3. Storage of sludge and scum until it can be removed.

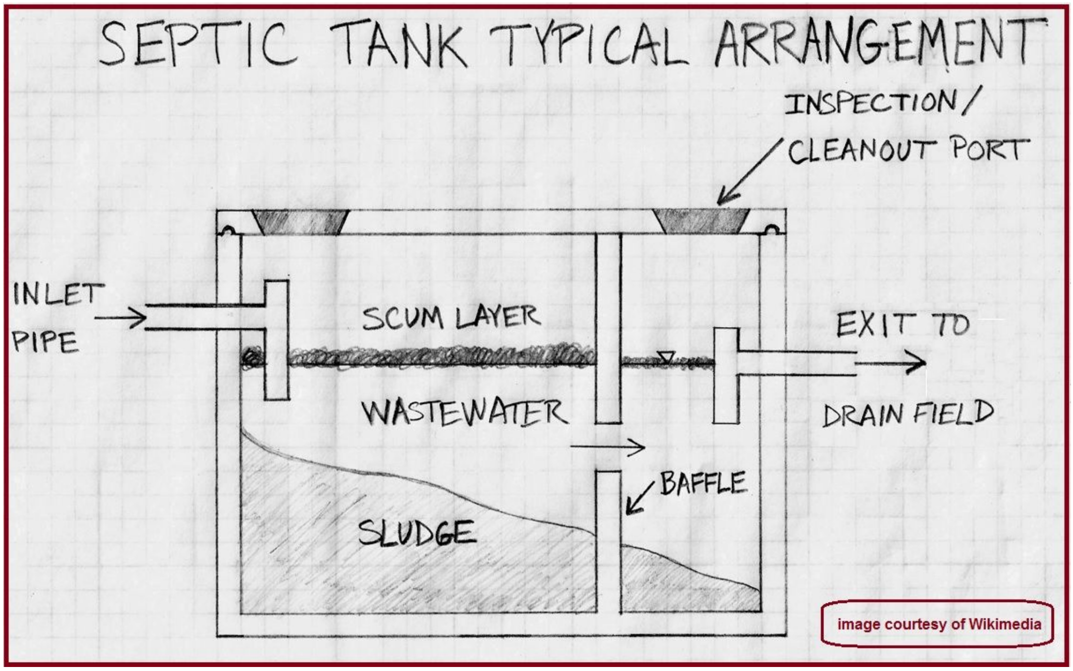
The most critical of these functions is its role as a settling tank. Unless allowed time and space to break up solids and allow them to settle, the resulting effluent will clog the pores of the soil in the leaching field. Very little purification is accomplished in the tank; the actual treatment and digestion of harmful waste materials takes place in the ground after discharge from the tank. The main role of the biological action is to liquefy the solids to the greatest extent possible, to facilitate dispersal from pipes and percolation through the soil. Unless solids are sufficiently reduced in the effluent, it will not only clog the distribution pipes but also clog the soil and not allow whatever parts are contained within the solid to be purified by physical and biochemical interaction with the soil. Although the sewage undergoes some treatment in passing through the tank, infectious agents remain. The effluent of a septic tank is NOT safe and is, in many respects, more objectionable than the influent, since it's now septic and malodorous. These conditions are not a malfunction or deficit; the primary purpose of the tank is simply to condition the raw sewage so that it will not clog the disposal field. Continued treatment and the removal of pathogens are accomplished by percolation through the soil. Disease-producing bacteria will die out after a time in the unfavorable environment of the soil. Bacteria are also removed by physical forces during filtration through the soil. These coil dynamics combine to achieve eventual purification of the septic tank effluent before it enters groundwater.

Sludge and Scum

The two terms, sludge and scum, would seem similar and both sound yucky. The distinction does matter, however. Simply put:

- ➔ Sludge sinks –
  - ◆ It is an accumulation of solids at the bottom of the tank.
  - ◆ Although it is not subject to the same biological processing as the effluent released to the drainfields, sludge is partially digested by bacteria as well as compacted into a smaller volume.
- ➔ Scum rises –
  - ◆ It is a partially submerged floating mat of solids at the surface of the liquid in the tank, composed mainly of oil and grease as well as some lighter organic compounds.
  - ◆ Scum will also be partially processed by bacteria to a greater or lesser degree dependent on its composition.

Regardless of the efficiency of the septic tank's operation, residua of inert solid material will always remain. Adequate space must be provided in the tank to store this residue between cleanings. Determination of when cleaning is needed can be verified by measuring the thickness of these two layers. If allowed to thicken past the point where the baffle opens to the drain field, sludge and scum will flow out of the tank with the effluent and clog the disposal field in a very short period of time.



A Note on Garbage Disposals

The modern food waste grinder (commonly called a “garbage disposal”) does not merely grind food wastes into disposable solids but literally liquefies them so that, when the resulting effluent enters the sanitary drainage system, it will flow through pipes in a similar manner to water. This facilitates drainage. The issue with regard to septic tanks is that, for some users, the opportunity to grind bones along with other food wastes means that bone fragments and other similar organic wastes that do not break down or are harder to break down in the septic tank are delivered.

In addition, effluent that has gone through a grinder has solids in suspension ground so fine that they don't settle well. This creates such a wealth of smaller organic wastes to the septic tank that bacterial growth is fostered, along with the resultant increased oxygen demand as they digest the organic matter. Although this enhanced treatment in the septic tank seems a benefit, it can also mean that the effluent released to the drainfield tends to have a more resistant biomat, resulting in a decrease in the long-term acceptance rate for the drainfield.

Septic tanks, therefore, will most likely function best where a food waste grinder is not used. Customers, however, are not likely to want to give up their garbage disposals. Where possible, they should, at least, be informed to use the food waste grinder in a way that won't overly burden the system (e.g., no bones) and that they probably need to arrange for the septic tank to be cleaned more often.

[SLIDECUT]

[QUESTIONHEADER]

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What is the estimated daily wastewater flow per bedroom, as delineated in the formula covered in this class (drawn from Wisconsin codes)?	100 gallons per bedroom	40 gallons per bedroom	60 gallons per bedroom	1,000 gallons per bedroom

[QUESTIONBOTTOM]

[SLIDECUT]

POWTS Design and Installation

The final lesson in this class will look a little more closely at the two major components of a POWTS – the septic tank and absorption field.

Septic Tanks

Location, Compartments, and Capacity

Don't site the tank anywhere it could cause contamination of any well, spring, or other source of water supply – never any closer than 50 feet from any water supply source – further than 50 feet where possible. Remember that underground contamination can travel in any direction for considerable distances unless effectively filtered. Never locate in a swampy area or wetlands and, if the area is subject to flooding, substantial flood-proofing protection is required to prevent the flood waters from transporting its contents to adjoining area. Locate tanks where the largest possible area for the disposal field is easily reached. Ease of maintenance and accessibility for cleaning are important factors to be considered. When it is anticipated that public sewers will be available in the future, provisions should be made for the eventual connection of the house sewer to such a public source.

Although there are some single-compartment tanks, a two-compartment tank provides better removal of suspended solids. The initial chamber should be anywhere from the same size to 150% of the size of the second chamber. Anything more than two compartments adds no utility and may not even perform as well as a two-compartment tank.

Sizing the tank should lean to larger dimensions, where possible. Larger sizing is not only desirable from a functional viewpoint but is sound, economically practice. The depth of the tank is less important than the volume, although any depth less than two feet would have difficulty in functioning well. The following sizing requirements provided by the ASPE include allowances for all household appliances, including food grinders.

Liquid Capacity of Tank (in gallons)		
# of Bedrooms	**Recommended Minimum Tank Capacity**	**Equivalent Capacity per Bedroom**
2 or less	750	375
3	900	300
4	1000	250
For each additional bedroom, add 250 gal.		

Tank Material and Backfill

Septic tanks must be watertight and constructed of materials resistant to excessive corrosion or decay. Acceptable materials are concrete, coated metal, vitrified clay, heavyweight concrete blocks, or hard-burned bricks. Precast septic tanks should have a minimum wall thickness of 3 inches, adequately reinforced to facilitate their handling. All concrete surfaces should be coated with an acceptable compound to minimize corrosion.

Backfill around septic tanks should be made in thin layers thoroughly tamped in a manner that will not produce undue strain on the septic tank. Settlement of the backfill may be done with the use of water, also filling the tank with water to provide sufficient weight.

Access and Tank Inlet and Outlet

Access should be provided to each compartment of the tank for cleaning and inspection by means of a removable cover or a 20-in. minimum size manhole. If the septic tank is more than 18 inches below finished grade, manholes and inspection holes must extend to the finished grade.

The inlet that empties untreated sanitary drainage into the septic tank should be at least 3 inches above the liquid level to allow for the liquid level to rise and fall. The free drop prevents backflow and sedimentary buildup. A vented inlet tee or baffle diverts the incoming sewage downward, terminating at least 6 inches below the liquid level of the septic tank (as long as it is not lower than the lowest level of the outlet device).

> A properly operating tank divides itself into three distinct layers: scum at the top, a middle layer free of solids (clear space), and sludge at the bottom layer. The space between the top of the tank and the baffle permits gas to pass through the tank into the building sanitary system and eventually to the atmosphere where it will not cause a nuisance.

The outlet fitting or device should penetrate the liquid level just far enough to provide a balance between the sludge and scum storage volumes. While the outlet tee or device retains the scum in the tank, it also limits the amount of sludge that can be retained without passing some of the sludge out with effluent. Best practices are for the outlet device to extend 35-40% of the depth of the liquid level into the bottom sludge layer.

Cleaning Septic Tanks

Septic tanks should be cleaned before too much sludge or scum accumulates and before sludge or scum approaches the bottom of the outlet pipe, which could result in solids flowing through the outlet device into the sewage disposal field, where it will clog the system. As unpleasant as this may seem, direct inspection of sludge and scum accumulation is the only way to tell when the tank needs to be pumped.

ENTRY OF THE TANK TO CLEAN IT IS EXTREMELY HAZARDOUS. When entering a large septic tank is necessary, be sure it’s been thoroughly ventilated of sewer gases. OSHA has rules against entering tanks without another person to act as monitor and either breathing apparatus or attachment to a tether to facilitate rescue, if needed.

Chemical Additives

No chemical additives are recommended for POWTS. Septic tank operation is not improved in any way by the addition of chemicals; and some products that claim to "clean" septic tanks contain sodium hydroxide or potassium hydroxide which may interfere with the biochemical action for which the tanks are intended. Worse, chemical-treated effluent can damage the soil and clog dispersal lines in the absorption field.

In contract, naturally occurring chemical contaminants, such as household bleach, soaps, drain cleaners, etc., should not interfere with the operation of a septic tank. If tanks are sufficiently sized, the dilution is enough to minimize any harmful effects. If in too great a concentration, these household chemicals could damage the drainage field. Toilet paper substitutes, paper towels, newspaper, wrapping paper, rags, and sticks should never be allowed to enter the septic tank. They may not decompose and are likely to lead to clogging.

Laws and Regulations

As mentioned earlier, most municipalities will have their own very specific set of laws and rules, including inspection and maintenance protocols. With regard to system design, several other requirements may be enforced, including the following:

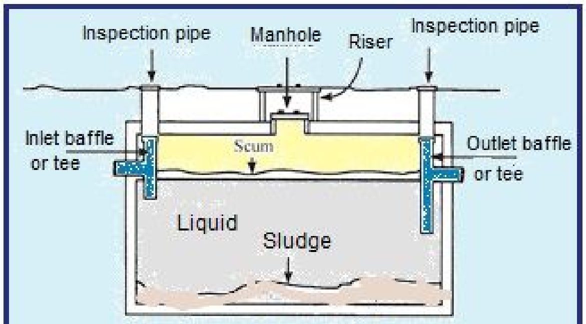
Frost protection

All POWTS components shall be protected from freezing temperatures that could detrimentally affect component operation to provide wastewater conveyance, treatment or dispersal.

Alarms or warning systems

- A POWTS component utilizing a mechanical device to treat wastewater or to distribute effluent shall be provided with an automatic visual or audible means of notifying the user of the POWTS of the failure of the mechanical device.
    - Note: An alarm that is electrically powered is to be on a separate circuit from the circuit supplying power to the mechanical device.
- An alarm indicating the failure of a pump shall remain audible or visible until manually turned off.
- Where duplex pumping equipment is employed to provide continuous component operation in the event that one pump fails, the pumps shall be installed in such a manner so as to provide the continuous operation automatically.
- A POWTS holding tank shall be provided with an automatic visual or audible means of notifying the user of the POWTS of the necessity for servicing.

Accessibility



Schematic of a septic tank
courtesy of Univ. of Nebraska - Lincoln

The design of a POWTS shall include provisions to provide access to all components that require maintenance or observation.

Anchoring system components

An exterior subsurface POWTS treatment tank or POWTS holding component to be installed in an area subject to saturated conditions shall be installed so as to prevent flotation of the tank or component.

Treatment byproducts

All treatment byproducts and effluent discharged from or as a result of operating a POWTS shall be disposed of in a manner conforming with the rules of the state agency having jurisdiction and dispersed so as not to create a human health hazard. (Sludge, scum and contaminated liquids must be disposed of pursuant to regulations).

There are also regulations covering service suction or discharge lines, including the requirement for a suction or discharge line to terminate with a service port identified as such with a permanent sign with lettering at least ½ inch in height, set at least 2 feet above final grade consisting of a quick disconnect fitting with a removable plug secured to a permanent support that is capable of withstanding the loads and forces placed on the port. A suction or discharge line must be at least 3” in diameter except that a discharge line from a lift station employed for servicing a holding tank may be at least 2” in diameter. The lift station pump must be activated by means of a keyed switch.

Soil Absorption Systems

Soil absorption fields are divided into what is known as “distribution cells”, each served by a supported perforated pipe or leaching chamber. The partially treated effluent discharges to underlying in-situ soil for treatment and dispersal to the environment. The soil beneath the pipe, to the depth required to treat water, is considered part of the cell.

Assessment of the suitability and relative absorption capacities of potential drainage fields is made considerably simpler by a long history of soil evaluation for agriculture. Soil surveys and maps by U.S. Department of Agriculture, when available, are a good way to start assessing drainage fields. More information can be gleaned by a visual inspection of the soil, looking for, among other things:

- Texture: Soil texture generally is defined as the relative proportion of sand, silt, and clay in the soil. It is the first clue to the soil’s infiltrative capacity. Generally large soil particles create large pores and a faster infiltration rate. Lighter or sandier soils have a gritty feel when rubbed between the thumb and forefinger. Silty soils have a floury feel and, when wet, have no cohesion. Heavier, clay-type soils are dense and hard when dry and have a slick, greasy feel when wet;

- Structure: Soil structure can be recognized by the manner in which a clod, or lump, breaks apart. Clods from soil with a well-defined structure will break along well-defined cleavage planes into uniformly sized units, and less well-defined will either crumble (if sandy) or refuse to break evenly (if high in clay);

- Color: Most soils contain some iron compounds, which oxidizes when alternately exposed to air and water, taking on a reddish brown or yellow color, which means effluent will also easily infiltrate;

- Depth (or thickness) of permeable strata;

- Boundary characteristics,

- Redoximorphic features (meaning a feature formed in the soil matrix by the processes of reduction, translocation, and oxidation of iron and manganese compounds in seasonally saturated soil – in other words, it is a kind of “mottling” of soil created by alternating wet and dry periods, and helps to assess historical hydrological conditions and determine the seasonal water table.)

Percolation Tests

The next step is to perform a percolation test. Without going into much detail, the following are key elements in this type of test:

- At least six test holes, 4 to 6 inches wide, evenly spaced through the field, are dug to the depth of the proposed drainage pipes or chambers. Two inches of coarse sand or fine gravel are laid at the bottom of the test holes.

- Clear water, at least 12 inches above the bottom layer of sand or gravel, is held for other than sandy soil in the hole for about 24 hours (replenishing after a few hours to compensate for horizontal leaching and evaporation). Sandy soil may only need to have the water held for 30 minutes to an hour. The goal is to measure how much the water level drops when surrounding soil has swelled to conditions similar to a rainy period.

- There are different protocols when there is no drop in water level or water seeps away too rapidly; these protocols are for more commonly occurring provisions.

The percolation rate helps determine how deep the soil must be to provide adequate time and space for decontamination of the effluent.

Site Preparation and Construction

Here are some tips:

1. The soil can’t be too wet, or it will compact too solidly below the trench to allow for reliable infiltration. If the soil at the infiltrative surface can be rolled into a ¼-inch wire, the site is too wet.

2. Avoid heavy equipment or heavy foot traffic to the soil at the bottom of the trench.

3. Use the land contours to your advantage and align cells so that they have the same elevation profile, where possible.

4. If stone aggregate is used as the supporting surface for the piping, place geotextile fabric over the stone aggregate.

5. Avoid backfilling the first 12 inches with rocks or objects that could damage the pipe or chamber.

6. Provide ground coverage that is protective and reduces evaporation but has no deep roots.

Seepage Pits

Seepage pits are an alternative to absorption fields, ONLY where such fields are unavailable or impractical. The bottom of the pit must be at least 4 feet above the groundwater table. The pits are constructed with striated layers of different types of soil. When more than one pit is required to obtain the necessary absorption area, pits should be no closer than a distance equivalent to three times the diameter of the larger pit. Material for the lining may be clay or concrete brick, block, or rings with weepholes or notches to provide for seepage. Distribution piping should be laid on a firm bed of undisturbed soil throughout their length and at a minimum grade of 2% (¼ inch per foot).

Alternative POWTS

There is increasing interest in alternative methods such as aerobic and mound systems, but the numbers of alternative systems installed are only a few thousand, nationwide, at the present time. The alternatives to conventional primary and secondary treatment include sand filtration and evapotranspiration. Sand filters have been used in sewage treatment for many years. More recently, standard systems have been modified to recirculating sand filter systems, which have demonstrated that, if properly designed, installed, and operated, they can produce effluents that meet stringent effluent and stream-quality standards. Evapotranspiration as a means of disposing of domestic wastes has been researched at several locations, and its use has been accepted by various local jurisdictions. However, this type of system is rarely used.

Utah Regulations

The regulations on Onsite Water Treatment Systems in Utah is fairly straightforward.

The primary regulations are available on the Utah Office of Administrative Codes website as Rule R317-4 [Onsite Wastewater Systems]. The Sections under this rule are as follows:

R317-4-1. Authority, Purpose, Scope, and Administrative Requirements.

R317-4-2. Definitions.

R317-4-3. General Standards, Prohibitions, Requirements, and Enforcement.

R317-4-4. Feasibility Determination.

R317-4-5. Plan Review and Permitting.

R317-4-6. Design Requirements.

R317-4-7. Construction and Installation.

R317-4-8. Final Inspections.

R317-4-9. Experimental Systems.

R317-4-10. Wastewater Holding Tanks Administrative, Design, and Installation.

R317-4-11. Operation and Maintenance of Systems.

R317-4-12. Variance to Design Requirements.

R317-4-13. Tables.

R317-4-14. Appendices

Appendix A. Septic Tank Construction

Appendix B. Pressure Distribution, Pumps, Controls, and Alarms

Appendix C. Soil Exploration Pits, Soil Logs, Soil Evaluations

Appendix D. Percolation Method

Appendix E. Tank Operation and Maintenance

Two of these Sections are reproduced, below:

R317-4-7. Construction and Installation

R317-4-7. Construction and Installation.
R317-4-7.1. System Installation.
A. Approved Plans.
The installer may not deviate from the approved plans or conditions of the construction permit without the approval of the designer and the reviewing regulatory authority.

B. Installation Restrictions.

A regulatory authority may limit the time period or area in which a system can be installed to ensure that soil conditions, weather, groundwater, or other conditions do not adversely affect the reliability of the system.

C. General Requirements.

1. Prior to installation, all minimum setback distances shall be field verified.

2. All absorption areas shall be protected prior to and during site construction.

3. The regulatory authority may require a temporary barrier around the absorption area, including the replacement area for additional protection prior to and during any site construction. If necessary, a more permanent barrier may be required following construction.

4. All absorption excavations and piping shall be level within a tolerance of plus or minus 1 inch. The overall slope from effluent entry to terminus shall be no more than 4 inches per hundred feet.

5. Absorption system excavations shall be made such that the soil in the bottom and sides of the excavation is not compacted. Strict attention shall be given to the protection of the natural absorption properties of the soil.

6. Absorption systems may not be excavated when the soil is wet enough to smear or compact easily.

7. All smeared or compacted surfaces should be raked to a depth of 1 inch, and loose material removed before the absorption system components are placed in the excavation.

8. Open absorption system excavations shall be protected from surface runoff to prevent the entrance of silt and debris.

9. Absorption systems shall be backfilled with earth that is free from stones 10 inches or more in diameter.

10. Distribution pipes may not be crushed or misaligned during backfilling. When backfilling, the earth shall be mounded slightly above the surface of the ground to allow for settlement and prevent depressions for surface ponding of water.

11. Final grading shall prevent ponding throughout the entire system area and promote surface water runoff.

12. Heavy wheeled equipment may not be driven in or over absorption systems prior to or during construction or backfilling.

D. Building and Effluent Sewer.

1. Pipe, pipe fittings, and similar materials comprising building and effluent sewers shall conform to the applicable standards as outlined in Section R317-4-13 Table 4.

2. Each length of pipe shall be stamped or marked as required by the International Plumbing Code.

3. Where two different sizes or types of pipe are connected, a proper type of fitting or conversion adapter shall be used.

4. All sewers:

a. shall have watertight, root-proof joints; and

b. may not receive any groundwater or surface runoff.

5. Pipes shall be installed on a foundation of undisturbed earth, or stabilized earth that is not subject to settling.

Construction and Installation, Part 2

R317-4-7. Construction and Installation.
R317-4-7.1. System Installation.
E. Tanks.
Tank installation shall conform to the following requirements.

1. All tanks shall be installed on a level, stable base that will not settle.

2. The hole to receive the tank shall be large enough to permit the proper placement of the tank and backfill.

3. Where groundwater, rock or other undesirable protruding obstructions are encountered, the bottom of the hole shall be excavated an additional 6 inches, and backfilled with sand, crushed stone, or gravel to the proper grade.

4. Backfill around and over the septic tank shall be placed in such a manner as to prevent undue strain or damage to the tank or connected pipes.

F. Absorption Systems.

1. Cover shall be evenly graded over the entire absorption area.

2. Distribution and Drop Boxes.

a. The inlet and outlet piping shall be sealed watertight to the sidewalls of the box.

b. The box shall be provided with a means of access. Access shall be brought to final grade.

c. The lid of the riser shall be adequate to prevent entrance of water, dirt or other foreign material, but made removable for observation and maintenance of the system.

d. The top of the box shall be at least 6 inches below final grade.

e. The box shall be installed on a level, stable base to ensure against tilting or settling, and to minimize movement from frost action.

f. Unused knock-out holes in boxes shall be sealed watertight.

3. The solid and distribution pipes shall be bedded true to line and grade, uniformly and continuously supported by firm, stable material.

4. No cracked, weakened, modified or otherwise damaged chamber or bundled synthetic aggregate units shall be used in any installation.

F. Pressure Distribution.
1. Installation practices shall follow the approved design.

G. Alternative Systems.
1. At-Grade and Mound Systems.

a. The site shall be cleared of surface vegetation, without removing soil, and scarified to an approximate depth of 6 inches. Any furrows resulting from the scarification shall be perpendicular to any slope on the site.

i. Rotary tilling is prohibited for scarification.

b. The system may not be installed in wet or moist soil conditions.

c. No equipment shall be driven over the scarified area.

d. The site shall be graded such that surface water drains away from the system and adjoining area.

2. Packed Bed Media and Sand Lined Trench Systems.
Installation practices shall follow the approved design.

R317-4-8. Final Inspections

R317-4-8.28.1. Final Inspections.
The regulatory authority shall inspect the entire installation before backfilling to determine compliance with this rule. Some components or system types require additional testing or inspection methods as outlined in the following.

A. Tank Water Tightness Testing.

Each tank shall be tested for water tightness prior to backfill.

1. The tanks shall be filled 24 hours before the inspection to allow stabilization of the water level. Considering water absorption by the concrete, there may not be a change in the water level nor any water moving visibly into or out of the tank. Testing shall be supervised by the regulatory authority. Tanks exhibiting obvious defects or leaks may not be approved unless such deficiencies are repaired to the satisfaction of the regulatory authority.

a. The regulatory authority may allow two piece tanks, with the joint below the water level, to be backfilled up to 3 inches below the joint to provide adequate support to the seam of the tank.

b. Polyethylene or fiberglass tanks may be backfilled as per manufacturers' recommendations.

2. If groundwater elevations inhibit the ability to visibly inspect the exterior of the tank, the tanks ay be tested by their ability to exclude water.

B. Distribution and Drop Boxes.

1. Distribution and drop boxes should be installed level and the flow distribution lines shall be checked by filling the boxes with water up to the outlets.

C. Pressure Distribution, Effluent Pumps.

1. Verify the correct operation of the pump, controls, and alarm.

D. Deep Wall Trenches, Seepage Pits.

1. Verify the depth of the trench excavation.

E. At Grade and Mound Systems.

1. Verify the preparation of the original ground before the placement of fill.
2. Verify that the final cover meets requirements.

F. Alternative and Experimental Systems.

1. All additional inspections will be dictated by the complexity of the system and absorption system type as identified by the regulatory authority.

G. Final Approval.

Final approval shall be issued by the regulatory authority prior to operation of the system, and shall include an as-built drawing of the completed system.

[SLIDECUT]

[QUESTIONHEADER]

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What is the best advice to give a POWTS owner about adding chemical “cleaning agents” such as potassium hydroxide to septic tanks?	They are likely to harm the tank’s effectiveness and should not be used	They are extraordinarily helpful and must be used at least once a month	They may help extend the time between tank emptying operations but are not necessary for any other purpose	They are useful in reducing unpleasant odors and can be used for this purpose but are not necessary for any other purpose

[QUESTIONBOTTOM]

[SLIDECUT]

[VIDEOHEADER]

End of the Class (Video)

That completes this class on Graywater Systems and Private Onsite Water Treatment Systems.

These two systems have three things in common –

➔ When well-designed, they can contribute greatly to water conservation and more efficient and cost-effective sanitary drainage and sewage systems;

➔ They’re among the most rapidly developing areas within the plumbing industry, with new and better ways to design and install these systems certain to become increasingly popular in the coming years; and

➔ They work best when regulations are responsive to popular sentiments so that fewer do-it-yourself or unregulated systems will be installed and the systems that are built meet the reasonable standards and regulations enforced by the community.

Thank you for taking this online education class from At Your Pace Online. Think of us whenever you or a colleague have future continuing education needs.

[VIDEOBOTTOM]

[SLIDECUT]

[QUESTIONHEADER]

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Redoximorphic means:	A mottling visible in soil caused by recurrent moist and dry periods	Formed by long periods of extremely high pressure	Containing more than one clearly demarcated stratum	A stratum of rock permeable to fluids

[QUESTIONBOTTOM]

[SLIDECUT]