Evaluation of
Potential Best Management Practices
-
Graywater Use in California Single and Multi-Residential Units

Prepared for

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AF	Acre Feet (325,851.429 gallons)
AWWA	American Water Works Association
BMP	Best Management Practice
BRAC	BRAC (Graywater Recycling) Systems
CALGreen	California Green Building Standards Code
CDC	Centers for Disease Control
CPC	Climate Prediction Center
CUWCC	California Urban Water Conservation Council
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EPA	United States Environmental Protection Agency
HCD	California Department of Housing and Community Development
GPCD	Gallons Per Capita Per Day
GPCY	Gallons per Capita per Year
LEED	Leadership in Energy and Environmental Design
LTL	Laundry To Landscape
MGD	Million Gallons per Day
MRU	Multi-Residential Unit
NRG	National Rainwater and Graywater
NSF	National Sanitary Foundation
SFPUC	San Francisco Public Utilities Commission
SRU	Single Residential Unit
UCLA	University of California, Los Angeles
UPC	Uniform Public Code
USGBC	United States Green Building Council
USGS	United States Geological Survey
US EPA	United States Environmental Protection Agency

1. INTRODUCTION

Responsible sustainable management of global water resources is one of the primary challenges of the 21st century. This is particularly true in California, where source waters and their ecosystems are stressed and degraded due to current management strategies in the face of agricultural needs, population growth, urban sprawl and climate change.

California has a history of naturally varying hydrological conditions. It is common for our region to experience short periods of wet weather, followed by extensive periods of drought. In the last 100 years, we have been in a drought for 35 years, roughly one third of the time.[1] Over the past decade, the average early snowpack in the Sierra Nevada, the main source of the state's water supply, has decreased by about 10%.[2] Given the state of water supplies in California, and the corresponding water quality issues, water conservation and water reuse strategies are necessary to institute as norms in California at all times, not just during drought periods.

Large areas of California are desert demanding nonlocal water sources for expansive human developments. Water supplies for Southern California travel distances up to 1800 miles from headwaters to destination, as exemplified as the Colorado's voyage to which San Diego. Other Southern California cities utilize water from the San Francisco Bay Delta (SFBD) and the Owens River Valley, moving 400 miles or more through large open canals in the Central Valley. Pumping this water up and over the Tehachapi Mountains to the Los Angeles Basin spends 2% of the state's total energy use.[3] This points to the intricate connection between water use and energy use – using one resource, always includes a corresponding use of the other resource.

Water users in California also acquire their water supplies from the ecologically crucial San Francisco Bay Delta, one of the largest estuaries on the western coasts of North and South America. Our best option is to participate as fellow-members of this ecosystem, as opposed to externalized managers, and consider how water conservation and water reuse is able to support maximum health of this important estuary.

Californians needs to make a concerted effort to both limit our draws on natural water bodies and control the quality of effluents sent back into the environment. Before considering alternatives to increasing the available water supply, we should

[1] Elizabeth Dougherty. April 12, 2012, Geek Out on UC Davis Australia vs. California Water Use Study, https://www.whollyh2o.org/daily-stream/integrated-water-management/item/441-geek-out-on-uc-davis-australia-vs-california-wateruse-study.html

[2] City of Palo Alto, Water Conservation – Residential, California's Water Conditions, (n.d.), http://www.cityofpaloalto.org/news/displaynews.asp?NewsID=473&targetid=139

[3] US EPA, Water-Energy Connection, (n.d.)

first ensure that the available water supply is being used efficiently. Employing water conservation and reuse strategies are crucial steps in protecting this vital riparian ecology.

When it comes to water security, the first step is to use and reuse water as many times as is safe and economical. The state of California and local jurisdictions should encourage safe and legal water reuse as it allows the maximization of water's utility on-site and encourages the treatment of used water prior to discharge. Graywater reuse at the domestic level is one of the simplest forms of water reuse and should be investigated and encouraged as a means to reduce the impact of residential developments on water resources.[4]

Graywater reuse contributes to resource efficiency and sustainable, localized water management. LEED, the International Code Council with "National Green Building Standard," and The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) with "Standard 189.1-2009 - Standard for the Design of High-Performance Green Buildings" all recognize the use of graywater to satisfy the option for water use reduction.

Legislative and executive drivers, such as the Clean Water Act, and the various iterations of Energy Policy Acts also point to water reuse as both water and energy sensitive strategies for reduction of demands on our resources.[5] Graywater has the potential to reduce the demand for new water supply, reduce the energy and carbon footprint of water services, and meet a wide range of social and economic needs. In particular, the reuse of graywater can help reduce demand for more costly high-quality potable water. Graywater also satisfies the adage, "Never use water once that you can use two or three times more."

Historically, in California, graywater systems have been installed largely as unpermitted, ad hoc systems designed by the residential water reusers. Art Ludwig of Oasis Design estimates that there are over 1.7 million illegal graywater systems in California.[6] These systems range from informal bucketing systems that convey water from shower "warm-up" water to laundry to landscape all the way through to systems that gather water from kitchen sinks and dishwashers.

Taking a graduated step towards facilitating safe and legal residential graywater use, in January 2010, the California Building Standards Commission adopted Title 24, Part 5, Chapter 16A into the California Plumbing Code. The new graywater code (now again under revision for the 2012 code revision cycle at the time of writing) addresses residential outdoor graywater use.

[4] Richard J. Scholze ard. September 30, 2011, *Public World Technical Bulletin 200-1-101: Graywater Applications for Army Installations*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf
[5] Ibid.
[6] Art Ludwig. Oasis Design, 2009, *Graywater to be legalized in California?* http://www.oasisdesign.net/greywater/press/index.htm#references

Title 24, Part 5, Chapter 16A - California Graywater Design Criteria

Chapter 16A establishes minimum requirements for the installation of graywater systems in occupancies regulated by the Department of Housing and Community Development (HCD). It is intended to provide guidance to code users while providing flexibility that will encourage the use of graywater. This part is applicable to occupancies under the authority of the Department of Housing and Community Development as specified in Section 108.2.1.1 and is intended to:

1. *Conserve water by facilitating greater reuse of laundry, shower, lavatory and similar sources of discharge for irrigation and/or indoor use.*
2. *Reduce the number of non-compliant graywater systems by making legal compliance easily achievable.*
3. *Provide guidance for avoiding potentially unhealthful conditions.*
4. *Provide an alternative way to relieve stress on a private sewage disposal system by diverting the graywater.*

The code facilitates increased potable water conservation, alleviates stress on residential septic systems, increases nonpotable water available for reuse for irrigation, toilet flushing, or simply groundwater recharge and provides guidelines for avoiding potentially unhealthful conditions.

Graywater from Residential Single Family Unit (RSFU) and Multi-Residential Family Units (MFRU) flows with blackwater (and stormwater, in combined systems) to a wastewater treatment plant, which then discharges the treated water to a local waterway. By appropriately matching water quality to water needs, Californians can reuse graywater on a local scale, supporting watershed health through natural water filtration and infiltration processes, while also reducing potable water use. Graywater reuse conserves energy resources as well, negating the energy needed to pump and treat water. Graywater users produce a smaller percentage of blackwater, decreasing the overall costs for water delivery and treatment. This results in reducing demand on limited supplies and contributes to obviating the need for building new treatment facilities.

Since the 2010 changes to the CA Plumbing Code, more cities and water agencies in CA have promoted and even subsidized graywater systems through rebates, incentives, and public education programs. Public education programs for policy makers, state and local government as well as the public will assist the trend toward incorporating graywater wherever appropriate. Internationally, Australia, Germany, Japan, and the United Kingdom are the current leaders in

the use of graywater.[7] Thus far, nationally, Arizona's 2002 law defining three-tiers of GW use are by far the most progressive.[8]

[7] Richard J. Scholze. September 30, 2011, *Public Works Technical Bulletin 200-1-101: Graywater Applications for Army Installations*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf
[8] Art Ludwig. (n.d.) *Arizona Gray Water Law,* http://www.oasisdesign.net/greywater/law/arizona/index.htm

2. WHAT IS GRAYWATER?

Graywater[9] is defined in various ways around the world. For instance, Canada, Australia, Queensland[10] and Europe define graywater as *(a)ny wash water that has been used in the home, except water from toilets, is called grey water. Dish, shower, sink, and laundry water comprise 50-80% of residential "waste" water. This may be reused for other purposes, especially landscape irrigation*.[11] Reviewing other definitions is useful in identifying further options for treatment and use of waters, such as kitchen sink effluent, which go beyond currently legal systems in California.

The State of California has it's own definition.

Graywater means untreated wastewater which has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and which does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. Graywater includes wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs but does not include wastewater from kitchen sinks or dishwashers. (CA Water Code: SECTION 14875-14877.3)[12]

As per the cited Water Code, in California, "graywater" is defined as water that comes from:

- bathroom sinks
- showers/tubs
- clothes washing machines

In California, graywater is not water that comes from a toilet or a kitchen sink. Water used in the kitchen sink is considered graywater in some states, blackwater in others, and dark gray in yet others due to the higher levels of grease, fat, and bacteria found in the water. In California, kitchen sink water is considered blackwater. As such, it's not a legally allowable source for graywater harvesting. With revisions to the code, this source of graywater could become another important source of water reuse, defraying yet more potable water use.

Graywater is sometimes confused with rainwater (water collected from roofs and other surfaces), which is often stored for later use. Graywater is not rainwater or

[9] Graywater is also spelled greywater, gray water and grey water.

[10] "Since 1 January 2008, appropriately treated graeywater can be used for other purposes such as toilet flushing, laundry use (cold water source to washing machines), vehicle washing, path or wall washdown and lawn and garden spray irrigation." Queensland Government. Department of Local Government and Planning, *Greywater Use* (n.d.), http://www.dlgp.qld.gov.au/plumbing/greywater-use.html

[11] Art Ludwig, Oasis Design, *What is Greywater*, (n.d.) http://www.oasisdesign.net/greywater/

[12] Department of Water Resources, *CA Water Code, Section 145875-14877.3*, (n.d.) http://www.leginfo.ca.gov/cgi-bin/displaycode?section=wat&group=14001-15000&file=14875-14877.3

rainwater's Janus face, stormwater. As we will later discuss, graywater should never be stored for over 24 hours, unless heavily filtered first

Graywater is also confused with blackwater (aka, sewage). Blackwater is water contaminated with fecal material, such as used toilet water (blackwater) and laundry loads of dirty diapers.

Graywater is also not recycled or reclaimed water, which is water from sewer treatment plants treated to various standards from nonpotable to potable for reuse.

Although graywater usually contains traces of dirt, food, grease, hair, and household cleaning products, it is a safe and even beneficial source of irrigation water, depending on the types of products used in the kitchen and bathroom. Graywater also provides an alternative supply for other non-potable water needs such as toilet flushing and clothes washing.

Graywater is an important component of integrated water management. When used in concert with conservation and efficiency, water wise landscaping, and rainwater harvesting, it can greatly lower potable water demand as well as the need for costly wastewater treatment. Graywater also serves for onsite groundwater replenishment. Graywater is a form of onsite (aka localized) water treatment.[13]

For the purposes of this BMP, we are addressing indoor and outdoor graywater production and use for single and multi-unit residential sectors.

[13] Wholly H2O, *Blackwater*, (n.d.) http://www.whollyh2o.org/blackwater.html

3. USING GRAYWATER

Graywater is a diverse water supply that serves a variety of on-site end uses. Each site must be evaluated to determine the most functional and economic use of graywater *in sitio*. In general, graywater can be used at the residential scale for all of the following purposes.

A. Guidelines for using graywater in California

- *Any graywater system that includes a connection to a potable or municipal water supply must have an approved, backflow prevention device. Laundry to landscape graywater irrigation systems that are exempt from permitting must have no connection to the potable water supply or an external pump.*
- *The graywater system design must include an accessible, clearly labeled, three-way valve that diverts the graywater back to the building sewer. Graywater should be diverted to the building sewer during the rainy season between November and April.*
- *Any graywater system that includes a connection to a potable or municipal water supply must have an approved, backflow prevention device. Laundry to landscape graywater irrigation systems that are exempt from permitting must have no connection to the potable water supply or an external pump.*
- *The graywater system design must include an accessible, clearly labeled, three-way valve that diverts the graywater back to the building sewer. Graywater should be diverted to the building sewer during the rainy season between November and April.*
- *The graywater must not leave the property where it came from or come within 100 feet of any creek, wetland, or waterway.*
- *The groundwater table must be lower than 3 feet from the lowest graywater irrigation or disposal point.*
- *Each release point must be covered with at least 2 inches of mulch, rock, soil, or a soil shield. Sprinkler irrigation and ponding of graywater are not allowed!*
- *Water used to wash diapers or other infectious garments must be diverted to the building sewer.*
- *Graywater may not contain hazardous chemicals.*
- *Graywater may not be used to irrigate root crops or other edible crops that touch the soil.*
- *An operations and maintenance manual for the graywater system must be provided by the installer and must be transferred to the new tenant or owner for the life of the graywater system.*
- *Graywater irrigation systems must be located a minimum horizontal distance away from the following landscape features:*

Figure 1. CA Graywater System Setback Requirements

Landscape Feature	Minimum Horizontal Distance from Graywater Irrigation System
Building structures	2 feet (610 mm)
Property line adjoining private property	1.5 feet (458 mm)
Water supply wells	100 (30,480 mm)
Streams Rivers, Lakes, Wetlands, and High Tide line of Ocean	100 feet (30,480 mm)
Sewage pits or cesspools	5 (1,524 mm)
Sewage disposal field	4 (1,219 mm)
Septic tank	5 (1,524 mm)
Onsite domestic water service line	0 (0 mm)
Pressurized public water main	10 (3,048 mm)

Source: Table modified from CA Central Coast Graywater Alliance: http://www.ecoact.org/Programs/Pollution_Prevention/Graywater/#irrigating

For detailed information regarding required setbacks for graywater tanks, graywater irrigation fields, and graywater disposal fields, see Table 16A-1 of Title 24, Part 5, Chapter 16A of the California Plumbing Code. [14]

Graywater systems are separated into three categories:

1. Single Fixture Clothes Washer

- *no permit required*

2. Single System

- *exceeds washer or single fixture system*
- *capacity is 250 gallons per day or less*
  construction permit required

3. Complex System

- *multi family or multi dwelling unit*

[14] Central Coast Graywater Alliance, *Guidelines for Irrigating with Graywater* (n.d.) http://www.ecoact.org/Programs/Pollution_Prevention/Graywater/#irrigating

- *capacity is greater than 250 gallons per day*
- *construction permit required*
- *construction Permits*

4. Applies for Small or Complex Systems

- *identify groundwater level and soil type for absorption qualities*
- *may use a 3 foot vertical test hole to show groundwater is lower than hole*
- *all components must be water tight*
- *must be inspected by enforcement agency*

Other local regulations and inspection requirements many apply (contact local enforcement agency)[15]

B. Graywater end uses, outdoor and indoor

Outdoor Use

- *year round irrigation*
- *backup irrigation during dry/drought periods*
- *year-round groundwater recharge*
- *firebreak in dry areas*

Graywater is an excellent water source to irrigate plants, trees, and shrubs. Graywater can be used for subsurface irrigation of ornamental plants, fruit trees, and lawns, and is best suited for use with mature plants (not saplings), which have considerable tolerance to salinity, sodium compounds, and high pH levels. It can also be used to irrigate vegetables or fruit-bearing plants/trees, but only if the edible portion does not come in contact with the graywater. Therefore root crops, such as potatoes, onions, garlic, carrots, etc are not candidates for graywater irrigation.

The most cost-effective residential graywater systems are simple, gravity-driven distribution systems that avoid the need for pumping, such as laundry-to-landscape (LTL), which utilize the washing machine pump to push water to outdoor irrigation distribution systems.[16]

[15] Appropedia, *California graywater regulations and design*, (n.d.) http://www.appropedia.org/Talk: California_greywater_regulations_and_design

[16] Richard J. Scholze, September 30 2011, *Graywater Application for Army Installations: Public Works Technical Bulletin: 200-1-101*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

Graywater is also an effective choice for localized groundwater recharge, depending on the level of the groundwater table. It can also provide a firebreak to residential and multi-residential properties.[17]

Indoor Use

- *Toilet flushing*
- *Clothes Washing*

Issues concerning graywater use for toilet flushing and clothes washing include fixture staining, water discoloration, water quality, safety hazard for children and pets, and odor. It is recommended that graywater be treated to prevent odors and discoloration of flush toilet fixtures, and to address any health-related concerns (e.g., splash back onto sensitive tissues).[18]

Graywater advocates have demonstrated that graywater from the final rinse of a clothes washer cycle can be reused as the first wash water for the next cycle which can then be sent out of the machine onto landscape thus providing three rounds of use for the same water. While this is a viable end use for graywater, technologies are not yet available for this type of reuse.

In 2009, the state of California passed the CA Plumbing Code, Chapter 16, Part A, which determined the legal use of graywater in outdoor residential settings. This code writing process brought new and renewed interest in the use of graywater in California. It also brought to the fore many of the impediments to the use of graywater, primarily voiced by public health officials and building and permitting departments.

According to Richard Scholze in his 2011 report on graywater for the US Army, the most common controversy and reluctance to graywater use is the potential health threat. However, "(t)here have been no cases reported to the Centers for Disease Control (CDC) related to graywater use."[19] Most graywater has a low enough concentration of contaminants and disease-causing microorganisms that it can be reused in applications without biological treatment or disinfection as long as the application has a low risk of direct public contact (e.g., subsurface irrigation and toilet or urinal flushing and when storage is not required).

Many of the potential risks to human health and other possible unfavorable side effects of graywater reuse such as encouraging breeding of mosquitoes, etc. can be reduced or eliminated by obviating storage. Also, graywater should be applied at a rate that the soil can absorb it to avoid saturation and pooling. Graywater

[17] Marsha Duttle, 1990, New Mexico State University, *Safe Use of Household Greywater*, http://aces.nmsu.edu/pubs/_m/m-106.html

[18] Richard J. Scholze, September 30 2011, *Graywater Application for Army Installations: Public Works Technical Bulletin: 200-1-101*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

[19] Ibid.

use emphasizes the need to understand the immediate on-site conditions and adapted to these, making graywater a contextualized, local water source.

C. System Permitting Requirements

Graywater system collects water from showers, sinks, or baths

- *Graywater system alters the plumbing (you cut into the drainage plumbing to access the graywater).*
- *Graywater system is installed in a building that is not a one- or two-unit residential building.*
- *Graywater system includes a pump (besides the washing machine's internal pump) or a tank.20*

D. Graywater Storage

Most SRUs do not require graywater storage, as the water is being distributed via LTL or branched drain systems to the exterior landscape immediately upon use. If residents use graywater for applications other than subsurface irrigation, such as toilet flushing, the graywater should not be stored unless treated and disinfected, and never for longer than 24 hours. Direct reuse without storage is highly recommended, as it minimizes the problems of microorganism growth and odor.

Should storage be necessary, as in MRUs, the tanks should be sized to empty completely within the first 24 hours after use, so as to alleviate fetid graywater sitting for more than 24 hours at the bottom to inoculate the next batch.[21] Design the system so that all pipes are at a gradient and angle all tank bases so that, if necessary, the entire system can be emptied of water.[22] Left untreated, stored graywater can quickly become septic and develop a population of anaerobic bacteria that will proliferate and create noxious odors.[23]

[20] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, http://sfwater.org/modules/showdocument.aspx?documentid=55

[21] Art Ludwig, Oasis Design, *Error: Storage of Grey Water*, (n.d.) http://www.oasisdesign.net/greywater/misinfo/index.htm#storage; Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywat*er, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf; Marsha Duttle, 1990, New Mexico State University, *Safe Use of Household Graywater*, http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/NewMexGWGuide.pdf; Richard J. Scholze, September 30 2011, *Graywater Application for Army Installations: Public Works Technical Bulletin: 200-1-101*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

[22] Richard J. Scholze, September 30 2011, *Graywater Application for Army Installations: Public Works Technical Bulletin: 200-1-101*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

[23] Art Ludwig, Oasis Design, (n.d.) *Error: Storage of Grey Water* http://www.oasisdesign.net/greywater/misinfo/index.htm#storage

E. Considering a Graywater System

The San Francisco Public Utility Commission (SFPUC) has created a useful guide for SRU or MRU residents in how to approach graywater harvesting:

Developing a Graywater System:

1. *Start with conservation! Conservation is always the most economical and environmentally beneficial place to begin. You might find that your landscape doesn't require as much water as you've been giving it, or that there are easy ways to greatly reduce the amount of water your household uses. If you are not able install an actual graywater system, you can still reuse water by collecting shower water in a bucket as the water heats up and using it to water your plants.*
2. *Determine which fixtures in your home are candidates for graywater capture. Washing machines are usually the easiest place to begin. Another potential fixture for graywater capture is the shower and bathtub faucet.*
3. *Analyze how water drains on your site and find out your soil type with a "soil ribbon test" and/or a low cost laboratory analysis (required if your system needs a permit). In combination with your flow calculations, this analysis will help you determine how large your graywater distribution system will need to be.*
4. *Read about types of graywater systems and decide which is best for you.*
5. *Draw a sketch of your proposed system. If a permit is required, you [may need to] submit a plot plan and details about the system to [your city or county's] Department of Building Inspection.*
6. *Find an installer or install the system yourself.*
7. *Remember to label the system (3-way valve and all above-ground graywater pipes) and keep an owner's manual with it.*
8. *Operate and maintain your system.*[24]

[24] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, (n.d.) http://sfwater.org/modules/showdocument.aspx?documentid=55

4. BENEFITS OF GRAYWATER USE

Graywater is beneficial both for residential water users, as well as for the environment. Graywater is a purely local water supply -– it is both produced onsite and used onsite as close to the point of production as possible. If graywater harvesting is appropriate for a site, it can provide a substantial quantity of local water for reuse.[25]

It's a waste to irrigate with great quantities of drinking water when plants thrive on used water containing small bits of compost. Unlike a lot of ecological stopgap measures, grey water reuse is a part of the fundamental solution to many ecological problems. -- Art Ludwig[26]

A. Potential Benefits

- Reduce potable water use by 40-65%, depending on the house/site
- Reduce water bills due to decrease in potable water use and sewer effluent output
- Reduce energy and chemicals used to treat the water to potable standards at the wastewater treatment plant
- Reduce household effluent sent to treatment plant – thereby reducing energy costs to treat and/or reuse water
- Improve quality of household effluent to waste treatment plant27
- Recover nutrients such as nitrogen and phosphorus
- Reduce dependency on imported water or local aquifers
- Improve Soil condition and plant growth with nutrients in the graywater, which can nearly match those of commercial fertilizers
- Increase groundwater recharge
- Encourage the use of nontoxic products

[25] Janet Nolasco, Pacific Institute, *Sustainable Water Management for Urban Agriculture: Planting Justice*, (n.d.), http://www.pacinst.org/reports/success_stories/sustainable_water_management_for_urban_agriculture.pdf

[26] Art Ludwig, Oasis Design, *Why use graywater*?, (n.d.) http://www.oasisdesign.net/greywater/;
Laura Allen, Wholly H2O, *Uses and benefits of Graywater*,(n.d.) http://www.whollyh2o.org/graywater/item/348-uses-and-benefits-of-graywater.html;
Let's Go Green, *Practical Alternatives to Sewer and Septic System*", (n.d.) http://www.letsgogreen.com/greywater-recycling.html;
Eco-friendly Mind, *Benefits of Gray Water Recycling*, http://www.whollyh2o.org/graywater/item/348-uses-and-benefits-of-graywater.html;
Joe Gelt, University of Arizona, *Home Use of Graywater, Rainwater Conserves Water--and May Save Money*, (n.d.) http://ag.arizona.edu/azwater/arroyo/071rain.html

[27] Bahman Sheik, WateReuse Foundation, 2010, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

- Connect people to their household water supply as well as to their watershed
- Alleviate stress on septic systems or treatment plants
- Provide drought insurance for landscape
- Provide a fire break and/or greenbelt of high-moisture species
- Gain LEED and Green Building Rating System points
- Take advantage of federal, state and local rebates and incentives
- Encourage knowledge of localized water use, treatment and reuse
- Encourage understanding of hydrologic cycle and local watersheds.

B. Potential Drawbacks

- May be more costly
- May decrease flow return to the sewage plant28
- While some people are concerned over the potential health hazards involved with gray water reclamation, its effects on our sewage systems concerns others. As most sewer systems were designed before gray water reclamation was an option, a lot of that wasted water is used to carry waste to sewage treatment facilities. If less water is available for treatment, less clean water will then be pumped back out into the water supply

[28] R. Penn, M. Schultze, E. Friedler, Grand Water Research Institute, February 2011, *Effects of Greywater Use on Municipal Sewer Systems*, http://gwri-ic.technion.ac.il/pdf/gwri_abstracts/2011/1.pdf

5. GRAYWATER TECHNOLOGIES

The 2009 California Plumbing Code for graywater states that the following are legal residential and multi-residential non-potable graywater systems:

There is a wide range of technologies from simple buckets to complex processes with storage tanks and treatment systems available for reusing graywater in residential and multi-residential contexts.[29] These include:

- *manual bucketing water spent while heating to a desired temperature,*
- *direct discharge of graywater from clothes washers, bathroom sinks, showers/baths to the building exterior for simple infiltration or for landscape irrigation*
- *piping bathroom sink graywater into toilet tank reservoirs.*

Some systems function without treatment, and others utilize technologies as complex as real treatment plants on a miniature scale. Many systems that a home or multi-unit owner can purchase commercially produce a filtered, disinfected product.

While current technologies around the world support a wide range of graywater sources and uses, not all are legal in California, as previously noted.

Laura Allen makes the point that all manufactured systems use plastic, pumps requiring electricity, maintenance and eventual replacement. If you have plants to water, use untreated graywater outside – you'll save money, time, and energy.[30] That said, graywater is a consistent and relatively readily available source of water, and toilet flushing a regularly needy source, making them well matched. Their practicality and cost effectiveness depends upon advances in technology.

As Art Ludwig points out, it is best to use graywater as close to the source and as soon as possible.[31] This makes graywater a truly local and immediate water source.

[29] Bahman Sheikh, WateReuse Foundation, 2010, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf
[30] Laura Allen, Greywater Action, *Manufactured Greywater Systems*, (n.d.) http://greywateraction.org/content/manufactured-greywater-systems
[31] Art Ludwig, *Common Grey Water Errors and Preferred Practices: An ongoing effort to counter the tidal wave of grey water misinformation on the web*, (n.d.) http://www.oasisdesign.net/greywater/misinfo/index.htm

A. Manual Bucketing

Figure 2. Manual Bucketing Graywater System

Source: Daniel Bowen, http://www.flickr.com/photos/danielbowen/

Manual bucketing is a practice that individuals employ to divert water from showers/baths and sinks, often while water is heating up, for non-potable uses. Manual bucketing is also used to capture graywater from a shower or sink after use. Both forms of bucketing are widely practiced and are common and promoted practices in Australia. It is generally not covered by any ordinance or code where it is being encouraged.[32]

Manually irrigating with greywater using a bucket (e.g. collecting shower and laundry water for reuse) has the potential to reuse small quantities of greywater, thereby saving drinking water. Bucketed greywater can be reused for irrigation of gardens, lawns and outdoor pot plants.[33]

The cost for manual bucketing is minimal based on finding or buying a bucket.

Manual bucketing is not addressed in the CPC 2009, but is encouraged by water agencies, such as the SFPUC.[34]

The amount of graywater available through this method depends on the length of time it takes for any individual shower/bath unit to produce hot water.

[32] Practically Green, *Place Bucket in Shower and Use Gray Water for Plants and Garden*, (n.d.) http://www.practicallygreen.com/actions/place-bucket-in-shower-and-use-runoff-to-water-plantsgarden; Sydney Water, *Ways Greywater Can Be Used*, (n.d.) http://www.sydneywater.com.au/water4life/inyourhome/GreyWater/GreywaterReuse.cfm

[33] Lane Cove Council, *Manual Bucketing Guidelines*, (n.d.) http://www.lanecove.nsw.gov.au/our%20environment/What%20can%20I%20do/Grey%20Water/documents/LCC-ManualBucketingGuidelines.pdf

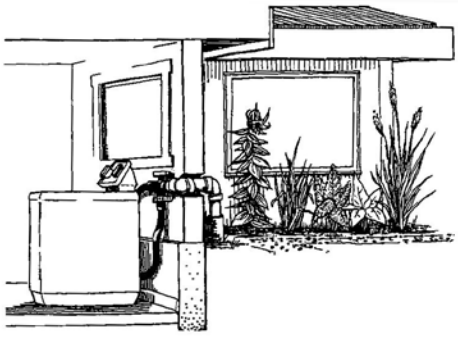
[34] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, (n.d.) http://sfwater.org/modules/showdocument.aspx?documentid=55

B. Direct Discharge

Laundry-to-Landscape

Laundry to landscape (LTL) graywater systems are one of the most simple and least expensive graywater systems that can be installed in single and multi-residential buildings. In all likelihood, they are the most commonly used system in California, along with manual bucketing.[35] These systems are also relatively inexpensive.[36]

Figure 3. Laundry-to-Landscape Graywater System



Source: SFPUC, http://sfwater.org/modules/showdocument.aspx?documentid=55

Laundry-to-Landscape is a washing machine-pressurized irrigation system. The basic concept is to divert graywater by a hose connected to the outlet of the clothes washer, and running this hose to reach the sub-surface irrigation area. Adjustable valves are then added as part of the distribution system to allow the graywater to empty into mulch basins around trees and plants.[37]

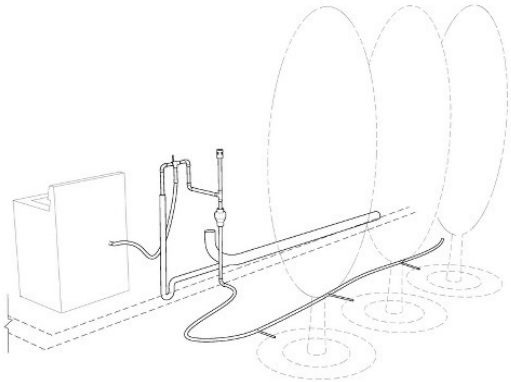
Laundry-to-landscape systems generally require no pumping, instead utilizing the washing machine pump and gravity to push the water into the soil through the exterior distribution system. These systems are useful where water is needed for irrigation or where pervious surfaces allow infiltration.

[35] Laura Allen, Wholly H2O, *Graywater Overview*, (n.d.) https://www.whollyh2o.org/graywater/overview.html

[36] Art Ludwig of Oasis Design originally designed the "Laundry to Landscape" systems. Oasis Design, Laundry to Landscape Grey Water System (also known as Laundry to Mulch Basins and Drumless Laundry Graywater System), (n.d.) http://www.oasisdesign.net/greywater/laundry/index.php

[37] Greywater Gardening, *Laundry to Landscape*, (n.d.) http://www.graywatergardening.com/Laundry_to_Landscape.html

Figure 4. Laundry-to-Landscape Graywater System



Source: Greywater Corps: http://greywatercorps.com/whatl2l.html

If Laundry to Landscape systems keep working as well as they have so far, most homes should have one. It is a cost-effective retrofit system, and renter-friendly. It can irrigate areas level with or slightly uphill from the washer. This is the system I recommend most often, usually in combination with a Branched Drain or Green Septic system.[38]

Collection potential in laundry to landscape systems varies according to the age and type of the clothes washer, as well as the number of wash loads per month that are appropriate for graywater (i.e. – no harmful chemicals or fecal material). Older top loading clothes washers use approximately 30 to 45 gallons of water per load. High efficiency clothes washers range from 3 to15 gallons of water per load.[39] A family of four using a standard sized clothes washer will generate more than approximately 300 loads per year. This equates to a non-efficient washing machine consuming approximately 12,000 gallons of water annually and a high efficiency approximately 3,600 gallons a year.

Figure 5. Laundry-to-Landscape Graywater Potential

System	System Variations	Gallons of Potable Water Used per Single Use	Number of times used by a Family of Four in a Year	Total Gallons of Graywater Availble per Year
Laundry-to-Landscape				
	Top Load Machine	30 - 45	300	9000 - 13,500
	Front Load Machine	3 - 15	300	900 - 4,500

[38] Art Ludwig, Oasis Design, *Laundry to Landscape Grey Water System*, (n.d.) *http://www.oasisdesign.net/greywater/laundry/.*

[39] Alliance for Water Efficiency, *Residential Clothes Washer Introductio*n, (n.d.) http://www.allianceforwaterefficiency.org/Residential_Clothes_Washer_Introduction.aspx

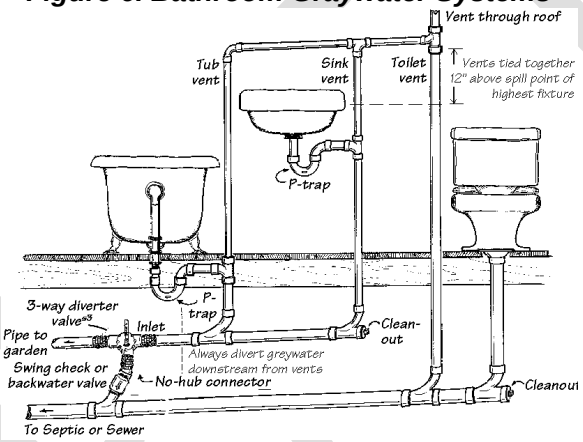
Source: Wholly H2O. 2012

In reality, a lesser percentage of these gallons that Californians produce in clothes washer use will be appropriate for graywater use, due to loads that include chemicals such as bleach and fabric softeners, as well as materials soiled with feces, reducing the probable total available for graywater.

Bathroom Sink, Shower, Bath to Exterior Landscape

Graywater can be distributed from the bathroom sink, shower or tub into the landscape, generally through a gravity-fed branched drain system. Graywater drains through a series of branching pipes and is dispersed into the landscape via mulch basin outlets. This system alters the existing plumbing and requires a permit.

Figure 6. Bathroom Graywater Systems



Source: Oasis Design, http://www.oasisdesign.net/greywater/stubout.htm

The case of shower/bath or sink to landscape varies from laundry to landscape in a number of ways, even if the graywater is being diverted to external landscaping or wetlands. This is because, unlike laundry to landscape, diverting graywater from a shower or tub requires cutting into existing plumbing. Depending on the height of the graywater source in relation to the distribution system, gravity may supply the "power supply" for moving graywater; however, it may also be necessary to add a pump. The state of California requires a permit for these types of diversion systems.

System costs can range from a few hundred dollars if installed by homeowner to a few thousand dollars if installed by a professional.[40]

Most simple and complex graywater systems from bathroom sinks, showers/tubs rely on gravity to move water through a branched drain irrigation system.

[40] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, (n.d.) http://sfwater.org/modules/showdocument.aspx?documentid=55

Graywater from showers, sinks, or laundry is directed to a temporary holding tank and then pumped to the landscape, which can be uphill of the graywater source(s). This system usually alters the existing plumbing and always requires a permit; an additional electrical permit might also be required for the outlet into which the pump is plugged.[41]

The potential for graywater capture from showers and bathrooms sinks in Figure 7 utilizes water use figures from EBMUD.[42]

Figure 7. Graywater Potential From Bathroom Water Use

System	System Variations	Gallons of Potable Water Used per Single Use	Number of times used by a Family of Four in a Year	Total Gallons of Graywater Availble per Year
Bathroom				
one sink use per person per day	Bathroom Sink	8	1460	11,680
one shower per person per day	Showers and Tubs	15	1460	21,900

Source: Wholly H2O, 2012

Cost without Pump: Ranges from a few hundred dollars if installed by homeowner to $1,000 to $2,000 if installed by a professional.

Additional Cost with Pump: Ranges from $500-$700 installed by homeowner to a few thousand dollars if installed by a professional.[43]

The California Plumbing Code exempts laundry to landscape systems only from construction permits where no modifications to the plumbing system are required or pumps are used in the graywater system. Systems must still meet the design and construction standards found in the regulations.

Clothes Washer, Bathroom Sink, Shower/Bath to Interior Toilet

Residents can harvest graywater from shower/bath and sink water directly into a toilet tank for flushing or into a receptacle that is then pumped into a toilet tank. This is very effective use of graywater in a residential building, particularly multi-unit buildings.[44] Graywater provides a continuous supply of harvested water for

[41] Ibid.

[42] Ryan Cahill and Jay Lund, November 2011, *Residential Water conservation in California and Australia,* http://watershed.ucdavis.edu/pdf/Cahill_Residential%20Water%20Conservation%20in%20Australia.pdf

[43] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, (n.d.) http://sfwater.org/modules/showdocument.aspx?documentid=55]

[44] Art Ludwig, Oasis Design, *Indoor Gray Water Reuse, Cascading, Gray Water Heat Recovery, and Rainwater Harvesting*, (n.d.) http://www.oasisdesign.net/greywater/indoors/; Eclissi Lifestyle, http://torreeclissi.com/en/eclissi-lifestyle/sustainability/

flushing toilets. The graywater supply can usually meet 100% of residential and multi-unit toilet flushing requirements, as well as being steady and predictable.[45] These systems are both home-designed and commercially available for maximum scalability.

Figure 8. Integrated Sink to Toilet Graywater System

Source: Smart Planet, http://www.smartplanet.com/blog/design-architecture/the-toilet-re-imagined-four-water-saving-designs/2013

There are some technologies, such as AquaCycle®, BRAC, and Aqus™ that have developed "tap to toilet" technologies, but we need more research to verify the ease and functionality in both SRUs and MRUs contexts.

However, it is very difficult to legally install an indoor toilet flushing graywater system in California. Graywater to Toilet systems require permits, which can difficult to procure from local agencies without knowledge or sufficient permitting guidelines. Additionally, and prohibitively, graywater from shower, baths and sinks must be treated to standards set in Title 22, Section 60301.230 before its reuse in toilet tanks, the same standards set for the treatment of wastewater and requires near daily water quality testing. For most residential and multi-family contexts, this requirement is a great deterrent to the installation of the systems, thus negating the practicality in terms of cost and time. California law-makers should reconsider aligning codes with realities and current technologies.[46]

[45] Wahaso Water Harvesting Solutions, *Greywater Harvesting Systems From Water Harvesting Solutions*, *(n.d.) http://www.wahaso.com/greywater_system.php.*

[46] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, (n.d.) http://sfwater.org/modules/showdocument.aspx?documentid=55; Sonoma County Water Agency, *Graywater*, (n.d.) http://www.scwa.ca.gov/graywater/

According to Figure 5, residential clothes washer, shower, bath and faucet water represent 60% of water used/graywater produced, available for use in toilets.[47]

Considering CA per capita water use of 124 GPCD, and California's population of 37,691,912, yields a total of 27,907,091,644.8 gallons or 85,643.6 AF available for graywater use for toilet flushing This is again with the caveat that not all of these water sources will be usable for graywater due to contamination from chemicals or feces.

Clothes Washer Final-to-First Wash Cycle

The final rinse water from a load of laundry can be used to supply the first wash cycle of the next load. This is not yet a widely practiced diversion in the United States and is not addressed in the CPC. However, relevant technologies are under development.

The potential quantity of graywater from these types of systems has not yet been documented. This is a very new technology and deserves research and documentation to be considered for use for graywater in California. It is particularly useful in SRU and MRU where landscaping is limited and does not offer sufficient opportunity to use all the graywater in a traditional LTL system.

Cost for these systems is not yet clear.

These systems are not currently covered in the CPC. [48]

C. Pipe Identification

There is much discussion about the proper color or marking of underground and visible piping for graywater. Thus far, the best way to mark graywater remains under dispute. The discussion regarding graywater pipe demarcation goes beyond the color of the pipe into the nature and classification of various reused waters, including rainwater, graywater, stormwater and blackwater. After trying various options, in 2009, the CPC adopted this language:

Chapter 16A, Section 1610.0, Valves and Piping reads:
Graywater distribution piping upstream of any connection to an irrigation or disposal valve shall be identified with the words "CAUTION: NON-POTABLE

[47] Laundry – 24%, Faucets – 16%, Bath – 2%, Showers – 18%

[48] Pete Melby, Tom Cathcart, 2002, *Regenerative Design Techniques*, Google On Line Books, http://books.google.com/books?id=YvExAYKnTc0C&pg=PA56&lpg=PA56&dq; E. Erikssona, E. Donnerb, Technical University of Denmark, May 2008, *Metals in Greywater: Sources, Presence and Removal Efficiencies*, http://www.desline.com/articoli/10591.pdf

WATER, DO NOT DRINK." Marking shall be at intervals not to exceed five (5) feet (1,524 mm).[49]

[49] California Department of Housing and Community Development, 2010, *California Plumbing Code, California Code of Regulations*, *Title 24, Part 5, Chapter 16A, Part 1* (GRAYWATER STANDARDS), http://www.hcd.ca.gov/codes/shl/ET_Emerg_Ch16A_Pt1_REV7-1-09.pdf

6. TREATMENT AND FILTRATION

A number of methods of filtration and treatment are available, although the type of treatment required should be determined by the quality of incoming water, the planned end use, and the degree of maintenance the system user desires. In SRUs and MRUs, treatment and filtration is necessary for only certain types of graywater end use. Neither a LTL Simple system nor a bathroom sink, shower/bath top branched drain or mulch basin requires filtration. However, if the graywater is for flushing toilets or moving into drip irrigation systems, filtration and treatment are required. In locations where using kitchen sink and garbage disposal graywater is legal, filtration and treatment are also called for.

The level of filtration necessary is determined both by the graywater source, as well as its intended end use. Given that California's graywater code does now allow kitchen sink or dishwasher water to be used for graywater, instead classifying these waters as blackwater, there no need for filtration when graywater is used directly in landscape (with the exception of drip systems). This is because mulch, soil, and plant roots are excellent at providing natural filtration for graywater.

However, if graywater will supply water for a drip irrigation system or for toilet flushing, filtration needs are more extensive. Each graywater and filtration system must be considered according to the site conditions (soil composition, terrain, and water table), source of graywater and use goals.

There are simple questions to ask in determining filtration needs.

- How much graywater does a household produce?
- What contaminants are present?
- What is the desired end use and how much does the household need?
- When is graywater needed for this end use?

Answering these questions will point to the type and size of system to install. The following chart from New Mexico State University speaks to the potential contaminants in various graywater sources, thereby indicating what might need to be filtered out depending on the intended end use.

Figure 9. Water-quality characteristics of selected domestic wastewater[50]

Water Source	Characteristics
Automatic Clothes Washer	Bleach, Foam, High pH, Hot water, Nitrate, Oil and Grease, Oxygen demand, Phosphate, Salinity, Soaps, Sodium, Suspended solids, and Turbidity
Automatic Dish Washer	Bacteria, Foam, Food particles, High pH, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Salinity, Soaps, Suspended solids, and Turbidity
Bath tub and shower	Bacteria, Hair, Hot water, Odor, Oil and grease, Oxygen demand, Soaps, Suspended solids, and Turbidity
Evaporative Cooler	Salinity
Sinks, including kitchen	Bacteria, Food particles, Hot water, Odor, Oil and grease, Organic matter, Oxygen demand, Soaps, Suspended solids, and Turbidity
Swimming Pool	Chlorine, and Salinity

Source: National Environmental Services Center, http://www.nesc.wvu.edu/pdf/WW/publications/pipline/PL_WI02.pdf

Now that the water source contaminants are defined, the next step is to identify what form of filtration is needed to remove each contaminant, if the end use dictates its removal. It's important to keep in mind that even in the case of the end goal being groundwater infiltration, that numerous contaminants survive filtration through roots and soil and can still contaminate ground water.[51] This is certainly the case with many pharmaceuticals and other toxins.

[50] Marsha Duttle, University of New Mexico, 1990, *Safe Use of Greywater, Guide M-106*, http://aces.nmsu.edu/pubs/_m/m-106.html

[51] Waterscape, *Residential Sources of Contamination*, (n.d.) http://www.waterscape.org/projects/vanduo/dw_gen/grdshort/src/resident.htm;

The next chart (Figure 10) identifies treatment options for a variety of substances if the end use necessitates removal. The options for filtration include filter systems built specifically for the residence's needs as well as commercially available graywater filtration systems. SRUs and MRUs will incorporate filters into toilet flushing systems. Those distributing graywater into landscape or wetlands do not need filtration, as the process occurs naturally.

The following systems may include settling tanks, storage tanks, filtration with activated charcoal, cellulose, or ceramic cartridge, and pumps.

Figure 10. Graywater Treatment Options

Treatment	Variable
Aeration	Odor, Organic matter, Oxygen demand, and pH
Alum	Soaps, and Turbidity
Carbon filtration	Odor
Chlorination	Bacteria, and Odor
Crop filtration	Bacteria, Food particles, Suspended solids, and Turbidity
Crop uptake	Nitrate, Phosphate, Soaps, and Sodium
Dilution	Hot water, Nitrate, pH, Phosphate, Salinity, and Sodium
Filtration	Food particles, Oil and grease, Organic matter, Soaps, Suspended solids, and Turbidity
Flotation	Oil and grease
Hydrogen peroxide	Bacteria, and Odor
Lime	Bacteria, Odor, and Sodium

Lentech, *Sources of Groundwater Pollution*, (n.d.) http://www.lenntech.com/groundwater/pollution-sources.htm; Wisconsin Groundwater Coordinating Council, 2002, *Residential Development and Groundwater Resources*, http://dnr.wi.gov/org/water/dwg/gw/pubs/SmartGrowth3.pdf;
University of Arizona, *Pharmaceuticals In Our Water Supplies: Are "Drugged Waters*: *a Water Quality Threat?*, http://ag.arizona.edu/azwater/awr/july00/feature1.htm;
Miranda S. Fram, Kenneth Belitz, May 2011, *Science of the Total Environment, Occurence and Concentration of Pharmaceutical Compounds in Groundwater used for Public Drinking-Water Supply in California*, http://ca.water.usgs.gov/pubs/frambelitz2011pharms.pdf

Settling	Foam, Food particles, Hot water, Organic matter, Oxygen demand, and Suspended solids
Soil filtration	Bacteria, Bleach, Chlorine, Foam, Food particles, Organic matter, Oxygen demand, Suspended solids, and Turbidity
Soil uptake	Nitrate, Phosphate, Soaps, and Sodium
Storage	Foam, Food particles, Hot water, Organic matter, Oxygen demand, pH, and Suspended solids[52]

Source: Pacific Institute, http://www.pacinst.org/reports/greywater_overview/greywater_overview.pdf

Often, the best solution is to design, install, and maintain a system so that the graywater needs no treatment at all. The reason why graywater is being considered as a substitute for potable water in the first place is because it is already relatively clean water source for reuse, particularly as landscape irrigation. Many of the substances contained in graywater are not harmful to plants, and some serve as nutrients for plant growth.

Interior use of graywater for toilet flushing or clothes washing necessitates filtration.

In the case of MRUs, even in large complexes, graywater for irrigation should be immediately released into the distribution systems if at all possible, or stored in a holding tank and completely released within 24 hours. When storage is required and large amounts of graywater are captured for reuse in toilets, filtration and treatment is necessary.

When installing a residential LTL system, pumped by the laundry machine directly into the branched drain water dispersal system, there is virtually no filtration needed, although some system users add a stocking to trap lint. However, stockings are not considered official filters.

In California, all systems that include a filter must be permitted.

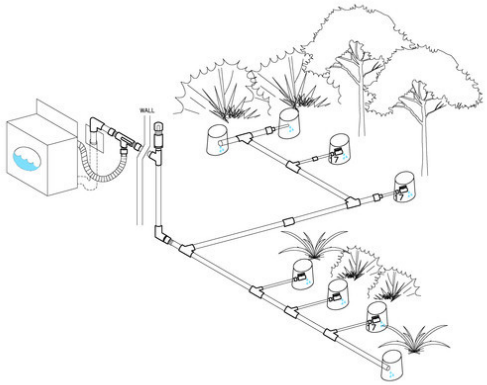
[52] Marsha Duttle, New Mexico State University, 1990, *Safe Use of Household Greywater Use*, http://aces.nmsu.edu/pubs/_m/m-106.html.

7. IRRIGATON DISTRIBUTION SYSTEMS

A. Laundry to Landscape, Simple System

A simple system distributes water from a clothes washer into a nearby mulch basin through a series of linked drip emitters in valve boxes.

Figure 11, Laundry-to-Landscape graywater System

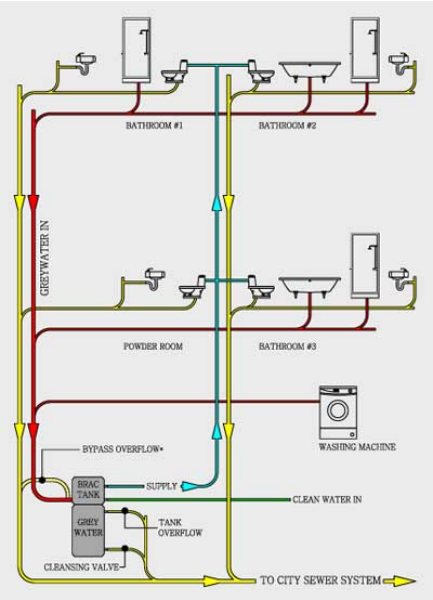


Source: Sustainable Water Management Wiki, http://sustwatermgmt.wikia.com/wiki/Greywater_Use_in_Santa_Barbara

B. Branched Drain

In a branched drain system, graywater from the bathroom sink and/or shower/bath drains through a series of branching pipes and is delivered to mulch basins in the landscape, where soil and plant roots filter the water. Showers, sinks and laundry can individually drain into the landscape, or be collected together into a single branched drain system.

Figure 12, Whole House Graywater System



Source: Sustainable Water Management Wiki, http://sustwatermgmt.wikia.com/wiki/Greywater_Use_in_Santa_Barbara

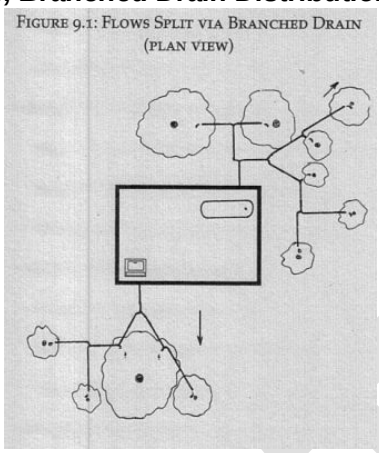
A branched-drain graywater system divides the flow into smaller and smaller branches. Branched drain systems do not require pumps or filtration, relying instead on a network of pipes and gravity to deliver graywater into the landscape where nearby soil and plants can filter the water. Showers, sinks and laundry can individually drain into the landscape, or be collected together into a single branched drain system.[53]

The graywater irrigation zone should be downhill relative to the graywater source to avoid pumping. Branched drain systems are best suited for irrigating food plants where graywater does not come into contact with the edible portion, trees, bushes, shrubs, and other larger perennial plants.[54]

[53] Clean Water Components, *Branched Drain Greywater System*, (n.d.) http://www.cleanwatercomponents.com/education/systems/branched-drain; John Russell, Watersprout, *Greywater Systems: Branched Drains*, (n.d.) http://watersprout.org/water_systems/greywater_systems/branched_drain_Etelson.html; Art Ludwig, Oasis Design, *Builder's Greywater Guide: Installation of Greywater Systems in New Construction and Remodeling*, (n.d.) http://www.oasisdesign.net/greywater/buildersguide/index.htm#brancheddrain

[54] San Francisco Public Utility Commission, *San Francisco Graywater Design Manual for Outdoor Irrigation*, http://sfwater.org/modules/showdocument.aspx?documentid=55;
Oasis Design, *Branched drain Greywater Systems*, http://www.oasisdesign.net/greywater/brancheddrain/index.htm;
Wholly H2O, *Typical Graywater Components*, http://www.whollyh2o.org/graywater/item/351-typical-components.html;

Figure 13, Branched Drain Distribution System



Source: Lets Go Green, http://www.letsgogreen.com/greywater-recycling.html

C. Drip Irrigation

Graywater systems that filter out particulate matter can direct graywater into a special drip irrigation system. Some systems require the user to manually clean the filter; other more complex systems have automatic filter cleaning built in. Usually designed by an engineering company, these systems filter graywater so it can pass through small emitters used in drip irrigation. Special graywater drip tubing is used. These systems are automated using timers to control irrigation zones. They are also plumbed to take in potable "make-up" water when there is not enough graywater to irrigate.[55]

Pumping, filtration, and backflow prevention increase overall system cost and maintenance, and increase the potential for permitting difficulties.[56]

Greywater Action, *Branched Drain Systems*, http://greywateraction.org/cat/image-galleries/greywater-recycling-images/branched-drain-systems.

[55] Laura Allen, Wholly H2O, *Uses and Benefits of Graywate*r, http://www.whollyh2o.org/graywater/item/348-uses-and-benefits-of-graywater.html

[56] Central Coast Graywater Alliance, *Guidelines for Irrigating with Graywater*, (n.d.) http://www.ecoact.org/Programs/Pollution_Prevention/Graywater/#permit

D. Treatment Wetlands

Figure 14, Treatment Wetlands

Source: Sustainable Sanitation, http://www.flickr.com/photos/gtzecosan/3212483747/

Treatment wetlands are graywater systems that divert graywater into treatment wetlands (also called graywater biofiltration systems), which serve as a soil-based filtration system. Graywater from bathtubs, showers, sinks, and washing machines infiltrates the soil filter where it undergoes biological treatment. These diversion systems typically involve some filtration to capture lint, hair, fats, grease, etc. when capturing water from bathroom sources or kitchen sinks.[57] Constructed wetlands can be used to treat graywater destined for the aquifer or a local creek, river, pond, or estuary, or to create backyard wildlife habitat. They can also be incorporated into more complex systems to treat water for toilet flushing.

Graywater system users can avoid the addition of pathogens, bacteria, and non-biodegradable toxins to surface water can be avoided with the biological treatment provided through wetlands, promoting a healthier ecosystem and more sanitary conditions.

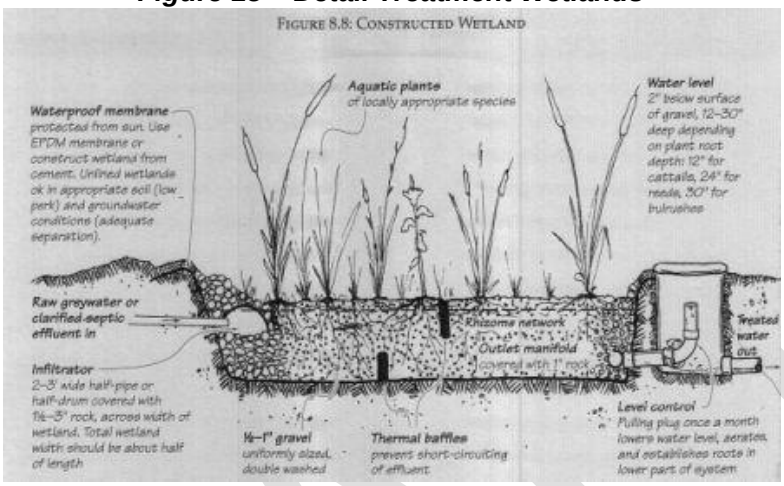
Investigations over several years document that E. coli concentrations were reduced by over 99% within the soil filter of wetland treatment systems.[58] That

[57] Lucy Allen, Juliet Christian-Smith, Meena Palaniappan, Pacific Institute, November 2010, *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management*, http://www.pacinst.org/reports/greywater_overview/greywater_overview.pdf;
Dayna Yocum, University of California, Santa Barbara, *Design Manual: Greywater Biofiltration Constructed Wetlands Guide*, http://fiesta.bren.ucsb.edu/~chiapas2/Water%20Management_files/Greywater%20Wetlands-1.pdf;

[58] Lucy Allen, Juliet Christian-Smith, Meena Palaniappan, Pacific Institute, November 2010, *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water" Management,*

said, Graywater Action makes the important point that *a residential greywater system should not contain toxins or dangerous pollutants.* Avoiding toxic cleaning products is the best way to keep household toxins out of your local ecosystem. Wetlands can remove or render harmless some industrial pollutants, but require constant monitoring and special design. Don't rely on simple backyard wetlands to treat household hazardous waste![59]

Figure 15 – Detail Treatment Wetlands



Source: Oasis Design, http:// http://oasisdesign.net/

The system can be built for a single household or a group of households, typically at a low cost.[60] The costs of wetland's graywater treatment can vary widely. Treatment wetland systems are therefore a useful option for multi-family housing as a larger amount of graywater can be treated to remove pollutants via infiltration through a constructed system. It should be noted that wetland treatment systems are land-intensive.[61]

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http://www.pacinst.org/reports/greywater_overview/greywater_overview.pdf;
Richard Schloze, September 2011, *Graywater Application for Army Installations*,
http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

[59] Greywater Action, *Wetland Information*, (n.d.) http://greywateraction.org/content/wetland-information

[60] Dana Yocum, University of California at Santa Barbara, *Design Manual: Greywater Biofiltration Constructed Wetland System*,
http://fiesta.bren.ucsb.edu/~chiapas2/Water%20Management_files/Greywater%20Wetlands-1.pdf

[61] Dana Yocum, University of California at Santa Barbara, *Design Manual: Greywater Biofiltration Constructed Wetland System*, (n.d.)
http://fiesta.bren.ucsb.edu/~chiapas2/Water%20Management_files/Greywater%20Wetlands-1.pdf;
Lonny Grafman, Appropedia, *Subsurface Flow Constructed Wetland for Greywater*, (n.d.)
http://www.appropedia.org/Subsurface_flow_constructed_wetland_for_greywater;
A.W. Jokerst, L. A. Roesner, and S.E. Sharvelle, Colorado State University, *An Evaluation of Graywater Reuse Utilizing a Constructed Wetland Treatment System*,
http://www.engr.colostate.edu/HHSLab/papers/EWRI_2009Paper_AJokerst.pdf; Federal Ministry for

The same code and permitting guidelines that address landscape in general are applicable to constructed wetlands.

Economic Cooperation and Development, *Technology Review of Constructed Wetlands: Subsurface Flow Constructed Wetlands for Greywater and Domestic Wastewater Treatment*, http://www.gtz.de/en/dokumente/giz2011-en-technology-review-constructed-wetlands.pdf; A. Gross, O. Shmueli, Z. Ronen, E. Raveh, *Recycled Vertical Flow Constructed Wetland (RVFCW) – A Novel Method of Recycling Greywater for Irrigation in Small Communities and Households*, http://www.stanford.edu/group/narratives/classes/08-09/CEE215/Projects/greendorm/water/GraywaterCD/graywater08/sdarticle.pdf and *Removal of Microorganisms from Domestic Greywater Using a Recycling Vertical Flow Constructed Wetland (RVFCW)*, http://www.environmental-expert.com/Files/5306/articles/13849/483.pdf; Graywater Action, *Wetland Information*, http://greywateraction.org/content/wetland-information; San Luis Obispo, *Guide to the Use of Graywater*, (n.d.) http://santalucia.sierraclub.org/documents/Graywater_08_20_09.pdf; Ronnie Frazer-Williams, Lisa Avery, Gideon Winward, Paul Jeffrey, Chris Shirley-Smith, Shuming Liu, Fayyaz Ali Memon, Bruce Jefferson, Cranfield University, *Constructed Wetlands for Urban Grey Water Recycling*, http://www.inderscience.com/search/index.php?action=record&rec_id=18470

8. IRRIGATING WITH GRAYWATER: IMPACTS ON PLANTS AND SOILS

Graywater, like rainwater, can be a naturally beneficial water source for landscape irrigation. The benefits of graywater on plants is also determined by what sorts of chemicals, soaps and additives are in the water from laundry machines, showers and bathroom sinks. Graywater contains many beneficial nutrients, such as nitrogen and phosphorus. The trick with graywater is to produce it responsibly, with an eye towards its end use.

Figure 16, Graywater in Use

Source: louisa_catlover; http://www.flickr.com/photos/louisa_catlover/2926974974/

Reusing graywater necessitates that homeowners educate themselves about which ingredients in their personal care and cleaning products are harmful and which are beneficial for the graywaters' end use, whether irrigation, toilet flushing or clothes washing.

A. Harmful Ingredients

Ingredients of personal care products and soaps can be beneficial to plants, particularly those that add phosphate and nitrogen, both needed by plants. However, too much phosphate will have a negative impact.[62]

[62] Brad Lancaster, Rainwater Harvesting for Drylands, *Soap and Detergent Info*, (n.d.) htttp://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/; Graywater Action, *Frequently Asked Questions*, (n.d.) http://greywateraction.org/faqs/greywater-recycling; Ecology Center, *Guide to Greywater-Compatible Cleaning Products*, (n.d.) http://ecologycenter.org/factsheets/greywater-cleaning-products.html

The State of California Department of Water Resources identifies specific ingredients to avoid, including:

- chlorine or bleach
- peroxygen
- sodium perborate
- sodium trypochlorite
- boron
- borax
- petroleum distillate
- alkylbenzene
- ”whiteners”
- ”softeners”
- ”enzymatic” components [63]

Primary ingredients to avoid are those containing sodium and boron. Sodium perborate and trypochlorite can add excessive amounts of salt to soil, which increases soil alkalinity. Alkalinity can reduce a plant roots' capacity to take up water, and can therefore dehydrate plants. Labels can lack specific quantities of sodium, so it is useful to know that in general, liquid soaps have less sodium than powdered soaps. Bleaches, disinfectants and germicides, even if from “natural” products, will impact soil health by killing living organisms.[64]

Usually, plants are healthier when the soil is allowed to dry out between irrigations. Therefore, for best results, one should wait until the soil in the root zone is half dried out before re-irrigating.

B. Graywater Compatible Plants

- Alkaline - loving well rooted plants
- Ornamentals
- Trees
- Fruit Trees
- Food Crops for which the graywater will not come into contact with the edible portion of the plant

C. Graywater Incompatible Plants

- Acidic soil-loving plants

[63] California Department of Water Resources, January 1995, *Graywater Guide: Using Graywater in Your Landscape*, http://www.water.ca.gov/wateruseefficiency/docs/graywater_guide_book.pdf
[64] Greywater Action, *Frequently Asked Questions*, (n.d.) http://greywateraction.org/faqs/greywater-recycling; Ecology Center, *Guide to Greywater-Compatible Cleaning Products*, (n.d.) http://ecologycenter.org/factsheets/greywater-cleaning-products.html

- Seedlings or young plants

C. Graywater Irrigation Issues

- Graywater and human contact don't mix. Therefore, any practice that would result in direct contact should be avoided – these include spraying graywater in overhead sprinklers, surface irrigation, pooling, and runoff.
- Graywater can easily and quickly clog drip systems without proper filtration and regular maintenance. Either remove solid particles from the water (by filtering or settlement) and increase the diameter of the holes in the irrigation pipe. It is recommended that drip irrigation hoses with small outlets not be used for graywater irrigation unless the solid particulates have been removed.
- Without regular rainfall or soil flushing, minerals such as salts can build up in the soil. With excessive rain, these additional minerals can runoff into natural waterways causing algae bloom.
- Graywater can add unwanted salts to water tables if the water table is high.

D. Maintaining Graywater Irrigation Zones

Flush soil with potable or fresh water periodically during extended periods of no rain in order to disperse minerals, such as salts, from building up.

Check for these issues and adjust graywater output accordingly:

- Damp and boggy ground hours after irrigation, and reduce graywater output if soil is overdamp surface ponding and run-off of irrigated water, reducing graywater output if necessary.
- Poor vegetation growth
- Excessive vegetative growth with reduced fruit
- Evidence of pests and diseases on plants
- Unusual odors
- Clumping of soil
- Fine sheet of clay covering the surface

9. COMMERCIALLY AVAILABLE SYSTEMS

As graywater gains popularity, an increasing number of vendors are offering graywater systems for various graywater sources and end uses, as well as individual parts such as storage tanks and filters. As previously discussed, in California, SRU graywater systems from a single fixture that discharges to soil, landscaping or treatment wetlands do not call for preassembled systems, but should be designed for the specific home, water source, point of reuse. In the case of MRUs, the same is true. In the case of complex systems, which collect graywater from more than one source or will be used for toilet flushing, a commercially available system will be appropriate.

There has been little research on the viability and cost effectiveness of these systems. Most of the available feedback is word of mouth that is unsubstantiated by data. Buyers are encouraged to do additional feasibility investigation and research.

The Alliance for Water Efficiency has identified a number of vendors in North America that are promoting systems. This list reviews complete systems, and does not include companies selling individual graywater system parts.[65]

Vendors

AquaCycle® by PONTOS®, independent subsidiary of Hansgrohe AG, Schiltach, Germany

- *Recycles graywater from lavatory sink, shower, tub and laundry for use in toilet flushing, clothes washing, cleaning, and on landscape*
- *Numerous existing installations in small and large residential and institutional applications*
- *Company contact (from North America): 011-49-7836-51 19 20*
- *info@pontos-aquacycle.com*
- *http://www.pontos-aquacycle.com/pontos/en/company/pontos.html*
- *Aqus™ Water Reuse System by WaterSaver Technologies, Louisville, KY*
- *Recycles graywater from lavatory sink for use in toilet flushing*
- *UPC (Uniform Plumbing Code) listed product*
- *Production and deliveries began in 2006*
- *Company contact: 502-741-1859*
- *info@watersavertech.com*
- *http://www.watersavertech.com/*

[65] Alliance for Water Efficiency, *Graywater Recovery and Treatment Systems*, (n.d.) http://www.allianceforwaterefficiency.org/Package_Graywater_Recovery_and_Treatment_Systems.aspx

BRAC Greywater Recycling System by BRAC Systems, Montreal Quebec

- *Recycles graywater from lavatory sink, shower, tub, and laundry for use in toilet flushing*
- *UPC (Uniform Plumbing Code) listed product*
- *In production*
- *Trial underway in Seattle*
- *Company contact: 866-494-2722 or 514-856-2722*
- *info@bracsystems.com*
- *http://www.bracsystems.com/home.html*

Ecoplay, Muiden, The Netherlands

- *Recycles graywater from shower and tub for use in toilet flushing*
- *Company contact (from North America): 011-31-294-26 43 11*
- *Not readily available in the U.S. at this time*
- *info@ecoplay.nl*
- *http://www.ecoplay.nl/en/index.html*

Econocycle: ultraGTS Domestic, Silverdale, New South Wales

- *Captures and recycles graywater from lavatory sink, shower, tub, and laundry for use in toilet flushing, landscape irrigation, and general cleaning*
- *System not yet available in North America*
- *Company contact (from North America): 011-02-4774-1256*
- *sales@econocycle.com.au*
- *http://www.econocycle.com.au*

Perpetual Water, Phillip ACT 2606 Australia

- *Captures and recycles graywater from lavatory sink, shower, tub, and laundry for use in toilet flushing, landscape irrigation, and general cleaning*
- *System not yet available in North America*
- *Company contact (from North America): 011-61-2-6162-0650*
- *sales@perpetualwater.com.au*
- *http://www.perpetualwater.com.au/*

ReWater by ReWater Systems, Inc., Chula Vista CA

- *Captures, filters and reuses shower, tub, lavatory sink, and laundry water for landscape irrigation*
- *Available since 1990; numerous existing installations with proven track record*
- *Company contact: 619-421-9121*
- *support@rewater.com*
- *http://www.rewater.com/*

Enviro-Friendly, Australia

- *Captures, filters, pumps graywater from laundry, sinks, showers. Also provides a tanks, bladders, rainwater harvesting equipment, solar hot water. Residential and Commercial.*
- *Available since: No information*
- *Contact Form: http://www.enviro-friendly.com/contact.shtml*
- *http://www.enviro-friendly.com/greywater-systems-australia.shtml*
- *Blog: http://enviro-friendly.com/blog/*

10. GRAYWATER SAVINGS POTENTIAL

A. Amount of Graywater Produced

Figure 17 – Illustration of Daily Water Use

Source: William Ishmael/Willpower Lifeforce, http://www.flickr.com/photos/williamismael/

Reusing graywater saves fresh potable water for other uses, reduces the volume of wastewater going to septic systems and wastewater treatment plants, and increases infrastructure capacity for new water users.[66]

When estimating graywater capture and reuse potential, the first question to answer is

- *how much graywater is available for reuse in any specific household over the course of a year?*

The percentage of household water that is graywater varies regionally and between households, depending on the primary uses of water in a home and how efficiently water is used, but is **generally between 50% and 80%** of the total household water usage.

As the charts below represent, even in advanced research reports, the water use numbers vary widely. Until more comprehensive studies become available with updates water use statistics, it is necessary to work with a range. The great variation in climate, as well as water accessibility are principal factors in California.

[66] USEPA, 2011, *EPA Water Recycling and Reuse: The Environmental Benefits,* http://www.epa.gov/region9/water/recycling/

The first chart demonstrates water use figures from the United States, EBMUD, and California. In all cases, residential irrigation is the highest percentage of potable water use.

Figure 18. Division of residential water use by category

			California			
Location:	United States		East Bay Area		California	
Source:	Mayer & DeOreo (1999)		EBMUD (2005)		DeOreo et al. (2011)	
Sample Size:	n = 1188		n = 33		n = 735	
End Use	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total
Toilet	70 (19)	11%	76 (20)	21%	48 (13)	10%
Shower/ Bath	48 (13)	7%	57 (15)	16%	49 (13)	10%
Washing Machine	57 (15)	9%	53 (14)	15%	39 (10)	8%
Faucets	41 (11)	6%	38 (10)	11%	42 (11)	9%
Leaks	36 (10)	6%	19 (5)	5%	39 (10)	8%
Other	16 (4)	3%	4 (1)	1%	7 (2)	1%
Outdoor	382 (101)	59%	114 (30)	32%	252 (67)	53%
Total	650 (172)	100%	360 (95)	100%	476 (126)	100%

Source: Cahill and Lund, Residential Water Conservation in Australia and California, November 2011, http://watershed.ucdavis.edu/pdf/Cahill_Residential%20Water%20Conservation%20in%20Australia.pdf

The chart below represents 2000 figures for estimated water use by end use in California. Without dividing the faucets into kitchen and bathroom, **55%** of residential water is available for graywater reuse.

Figure 19. Division of residential water use by category

End Use	Current Use (AF/yr)	Fraction of Total Indoor Use (%)
Toilets	734,000	32
Showers	496,000	22
Washing Machines	330,000	14
Dishwashers	28,000	1
Leaks	285,000	12
Faucets	423,000	19
Total Indoor Residential Use	**2,296,000**	**100**

Source: Pacific Institute, Estimated Current Indoor Residential Water Use in California, 2000, http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

Based on the 1999 AWWA residential water use study, Bahman Sheikh estimated graywater production at **38.7 gpgd** in 1999, and well as projecting a rise to **75.5 gpcd** in 2030.

Figure 20. Potential Graywater Generation in 1999 and 2035

Source or Total	% of Indoor Use	Graywater Generation Rate		
		Gal/per capita/day	Gal/household/day, 1999	Gal/household/day, 2030 (est.)
Clothes Washers	21.6%	15.0	40	22.5
Showers	16.7%	11.6	30	25.0
Baths	1.7%	1.2	3	3.0
Faucets	15.7%	10.9	28	25.0
Total Graywater	50.6%	38.7	100	75.5

Source: Sheikh, White Paper on Graywater, 2010, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

The University of Arizona and the University of New[67] approximate that **65%** of indoor residential water use could be recycled as graywater.

According to Sydney Water, approximately **61%** of the total blackwater produced by an average household can be used as graywater. [68]

A SFU or MFU owner can estimate their specific water reuse potential with various tools, such as water footprinting.[69] Owners can also have a professional water audit company perform an onsite water audit. Additionally, there are also specific onsite water measurement tactics that any household residents can employ to determine their specific water use and what amount of graywater is available from showers, baths, bathroom sinks, and clothes washers.

Perhaps the best potential source for water use calculations per residence is the water agencies themselves. As California water agencies continue to tie water rates to water use, they are providing water budget tools and services for their customers, assisting in providing accurate and well documented water use. Metering houses and gardens separately also assists in identifying the division of water use, and will contribute to more accurate estimations of graywater's potential to offset potable water use.

In addition, as appliance efficiency increases and conservation practices take hold, there will be less graywater produced available for reuse. At the same time, there are an increasing number of standardized systems being developed and introduced in the United States. Both of these factors will impact the cost effectiveness of installing graywater systems. Pilot studies are needed to determine cost effectiveness of graywater use in various use situations, with

[67] Marsha Duttle, University of New Mexico, 1990, *Safe Use of Greywater, Guide M-106*, http://aces.nmsu.edu/pubs/_m/m-106.html

[68] These figures *do* not include water estimates from kitchen sinks and/or toilets.

[69] Water Footprint, (n.d.), *Extended Calculator,* http://www.waterfootprint.org/?page=cal/WaterFootprintCalculator

water efficient appliances in place, and with a variety of graywater uses, including toilet flushing.

B. Offsetting Potable Water Use with Graywater

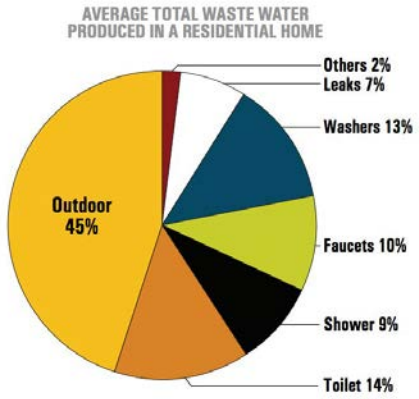
The second determination to make is:

- *how much of the potable water use could be offset with graywater produced on site.*

This amount varies across studies.

- ***The City of Tucson** expects that between 30% of typical household blackwater can be re-used as graywater for landscape.*[70] *Of the total amount of waste water produced in a typical home, 13% is from the washers, 10% is from faucets and 9% is from showers totaling 32% that can be re-used as graywater.*

Figure 21. Average Daily Water Use in Tucson



Source: City of Tucson, Ordinance 10579, www.tucsonaz.gov/agdocs/20080923/sept23-08-527a.pdf

- As stated in the City of Tucson's Graywater Rebate Program, if all graywater sources are used, it can replace 45% of the landscape irrigation needs of an average single family home. As always, this number varies widely based on irrigation efficiency, local climate, household occupancy, occupants habits, lot size and extent of landscaping.[71]

[70] City of Tucson, (n.d.) *Single Family Residence Gray Water Rebate Program*, http://cms3.tucsonaz.gov/water/gray-water;
City of Tucson, 2010, *Gray Water Professional Information Guide - City of Tucson*, cms3.tucsonaz.gov/sites/default/.../Booklet%20final%200910_1.pdf
[71] City of Tucson, (n.d.) *Single Family Residence Gray Water Rebate Program*, http://cms3.tucsonaz.gov/water/gray-water

- The **AWWA Research Foundation** 1999 research stated that homes with access to alternative sources of irrigation reduce their water bills by as much as 25%.[72]
- **The City of Long Beach** estimated in 2011 that by using indoor water for landscapes, overall potable water use could decline by 14-40%. Long Beach encourages graywater in its statement, such savings would represent a fundamental shift in Long Beach's demand and continue our reputation as a national leader in conservation. [73]
- **The WaterReuse Foundation**'s 2010 White Paper on Graywater states that graywater can offset potable water demands of a SRU or MRU, accounting for as much as 50% - 100% of the indoor potable water use and meeting about 50% for outdoor irrigation use during the irrigation season.[74]
- The Los Angeles' Office of Water Reclamation pilot study concluded that the amount of water saved in six of the eight residential sites metered over a 12-month period ranged from 2.2 to 11% of the total water use at the sites.
- **The San Francisco Public Utilities Commission** has done a comparatively in-depth study of onsite nonpotable water use potentials, laying a foundation for further estimations of graywater reuse. Both SFU and MFU are included in these figures.

Figure 22. Theoretical Use of Onsite Supplies

Year	Single Family Residential (MGD)		Multi Family Residential (MGD)		Non-Residential (MGD)		Municipal Irrigation (MGD)	Total (MGD)
	Existing	New	Existing	New	Existing	New	Existing	
2015	0.24	0.01	0.05	0.04	0.09	0.00	Not Applicable	**0.43**
2020	0.38	0.03	0.10	0.14	0.17	0.02		**0.84**
2025	0.47	0.08	0.15	0.29	0.25	0.04		**1.27**
2030	0.53	0.13	0.20	0.42	0.33	0.07		**1.68**
2035	0.66	0.20	0.25	0.65	0.40	0.12		**2.28**

Source: San Francisco Public Utility Commission, Potable Offset Investigation Summary, 2012, sfwater.org/Modules/ShowDocument.aspx?documentID=2225

These numbers reflect an assumption of significant customer participation.

The second figure outlines the potential savings according to numbers of systems in 2035. It summarizes the number of graywater systems that would be needed to achieve this level of onsite supply usage. As shown in this table, in

[72] The American Water Works Association Research Foundation (AWWARF), 1999, *The Residential End Uses of Water study (REUWS)*. http://www.allianceforwaterefficiency.org/residential-end-uses-of-water-study-1999.aspx

[73] City of Long Beach, August 23, 2011, *"Laundry to Landscape' Graywater Pilot Program*, http://www.longbeach.gov/news/displaynews.asp?NewsID=5414&targetid=55

[74] Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

order to achieve an onsite supply usage of 2.28 MGD, more than 260,000 systems would need to be installed. It should be noted that the SFPUC does not consider these as feasible numbers as it would require 100% customer participation.

Figure 23. Number of Systems Required

	Single Family Residential		Multi-Family		Non- Residential		Municipal Irrigation
	205 Gallons	2,000 Gallons	205 Gallons	12,000 Gallons	205 Gallons	12,000 Gallons	12,000 Gallons
System Type	Outdoor	Indoor / Outdoor	Outdoor	Indoor / Outdoor	Outdoor	Indoor / Outdoor	N/A
Total no. of Systems	110,759	6,916	86,499	9,924	32,211	13,874	N/A
Total Nonpotable Supply Used (MGD)	0.659	0.201153	0.25	0.65	0.40	0.12	N/A

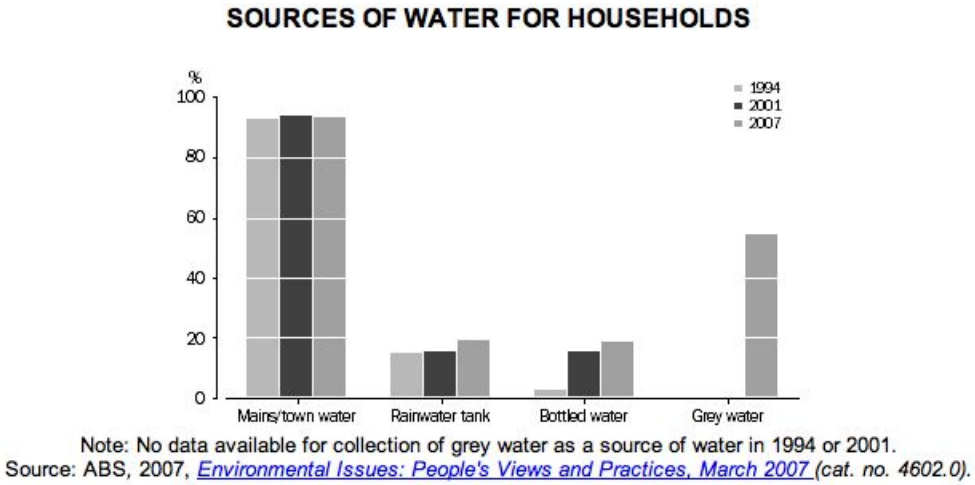
Notes:

1. *This scenario reflects an upper bound of onsite supply use, and is not considered achievable. This level of onsite nonpotable use would require ALL customers to participate in graywater reuse programs as outlined in Appendix D.*

Source: San Francisco Public Utility Commission, Potable Offset Investigation Summary, 2012, sfwater.org/Modules/ShowDocument.aspx?documentID=2225

According to the Australian Bureau of Statistics, in 2007, grey water was the second most common source of water for households, after mains/town water. More than half (54%) of Australian households reported grey water as a source.

Figure 24. Australian Water Source 2007



Note: No data available for collection of grey water as a source of water in 1994 or 2001.
Source: ABS, 2007, *Environmental Issues: People's Views and Practices, March 2007 (cat. no. 4602.0).*

Source: Australian Bureau of Statistics, Water Conservation, 2010, http://www.abs.gov.au/ausstats/abs@.nsf/lookup/4613.0chapter75jan+2010

Victoria had the highest percentage of households reporting grey water as a source at **72%,** followed by the Australian Capital Territory at **63%**. The Northern Territory had the lowest reported use of grey water, but this was still substantial at

almost a third of households at **32%**. In Tasmania, **37%**, just over a third**,** of households reported using graywater. [75]

As expressed in the Australian figures ranging from 37-72% of homes using graywater, it is obvious that the potential grows as available water supply diminishes and values shift.

The variation in figures of percentage of potable water use that can be offset by graywater makes obvious that the potential will vary depending on the water efficiency of the fixtures producing graywater and the household's irrigation water budget. These figures may change over time for any SFU or MFU that increases water conservation

C. Research on Potential Water Savings Via Graywater Use

Research from the UCLA Institute of Environment and Sustainability suggests dividing residential graywater into three tiers of graywater reuse.

- Tier 1 includes laundry water.
- Tier 2 includes the first tier and adds to it shower water.
- Tier 3 includes the first two tiers then adds to it dishwasher and faucet water.
- Tiers 1 and 2 are considered light graywater - blackwater from the shower, bath, bathroom sink, and clothes washing machine.
- Tier 3 is considered heavy graywater - blackwater from the kitchen sink and dishwasher.

The research suggests that reusing all of *Tier 1* and *Tier 2* graywater would be sufficient to meet 100% outdoor water use in Southern California.

If heavy graywater were also used, this would meet up to 41% of toilet water use provided this heavy graywater underwent treatment before use. Therefore, the estimated residential per capita potable water savings range would be wide but also quite significant at 16% - 40% for *Tiers 1-3***.**[76]

Graywater potential is a fluid research area as water fixture use figures shift commensurate with rapid technology upgrades, thus impacting the percentage of both graywater produced and graywater needed. As different end uses are adopted in California, this will also change figures. This is important to note, particularly for water agencies including graywater in their Urban Water Management Plans for water conservation and reuse to meet future water demands.

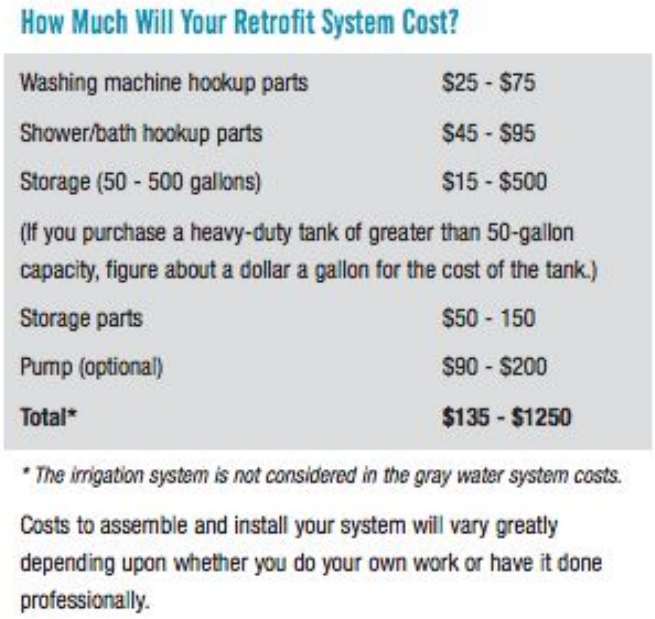
[75] Australian Bureau of Statistics, January 28, 2010, *4613.0 – Australia's Environment: Issues, Trends: Water Conservation*, http://www.abs.gov.au/ausstats/abs@.nsf/lookup/4613.0chapter75jan+2010
[76] Yorum Cohen, UCLA Institute of the Environment and Sustainability, 2009, *Graywater- A Potential Source of Water*, http://www.environment.ucla.edu/reportcard/article.asp?parentid=4870

D. Cost Effectiveness

Studies show that graywater systems can result in significant cost savings for homeowners and industry.[77] Depending on the complexity of a gray water reuse system, the cost of retrofitting an existing home with separate plumbing, storage, and treatment may be perceived as too expensive, depending on the current regional cost of tap water and the availability of retrofitting incentives. The ease with which a legal, properly designed gray water system can be installed in a given location may be a major factor in homeowner or builder choice. If codes are vague or contradictory, or if permitting staff and contractors do not have knowledge and experience with gray water systems, the process of installing and permitting could be difficult. The willingness of homeowners to incur the expense associated with maintenance and/or installation of gray water systems is central to widespread voluntary adoption.

The University of Florida has provided estimations for parts only. Given that many current graywater systems are laundry-to-landscape and relatively easy to install, these remain the cheapest to install, even with labor included.

Figure 25. Retrofit System Parts Costs



How Much Will Your Retrofit System Cost?

Washing machine hookup parts	$25 - $75
Shower/bath hookup parts	$45 - $95
Storage (50 - 500 gallons)	$15 - $500
(If you purchase a heavy-duty tank of greater than 50-gallon capacity, figure about a dollar a gallon for the cost of the tank.)	
Storage parts	$50 - 150
Pump (optional)	$90 - $200
Total*	**$135 - $1250**

** The irrigation system is not considered in the gray water system costs.*

Costs to assemble and install your system will vary greatly depending upon whether you do your own work or have it done professionally.

[77] Kreysig, D. *Greywater recycling: treatment techniques and cost savings. Water Conservation Recycling* 19(3):18–19. (1996)

Figure 26. Storage Costs

Storage (50 - 500 gallons)	$15 - $500
(If you purchase a heavy-duty tank of greater than 50-gallon capacity, figure about a dollar a gallon for the cost of the tank.)	
Storage parts	$50 - 150
Pump (optional)	$90 - $200
Total*	**$65 - $650**

Source: University of Florida, ISFA Extension, Gray Water Use in Florida

The cost-effectiveness of graywater systems varies widely, depending on the sophistication of the system, cost of potable water saved, and cost of permitting and labor for retrofit or new construction. All of these costs are in constant fluctuation. By following the City of Tucson, which has mandated all new residential construction to include stub-outs and drains to facilitate for graywater reuse, the cost for installing new systems to new homeowners will be greatly diminished.

Even the simplest system may not be cost-effective based only on the cost of water saved. However, there are also embedded "costs" of *not* using graywater to offset potable water use in a drought-prone state such as California. The state of California and water agencies are continually seeking "new" sources of water, whether by adding financial and energy intensive channels to the SF Bay Delta, or building a desalination plant. The cost benefits of *not* turning to large infrastructure projects by utilizing graywater on a wide-scale residential and multi-residential should also be considered, in terms of system costs. There is also the cost to of continually restoring riparian ecosystems faced with over-large water demands in order to ensure water quality as well as ecosystem biodiversity.

In 1999, California's DWR conducted another pilot study at three disparate sites and the costs of the systems installed far exceeded the value of the 20-year water savings.[78] A simple benefit–cost analysis indicates that the monetary benefits alone did not justify the costs of these three systems.

[78] Alison Whitney, Richard Bennet, Carlos Arturo Carvajal, Marsha Prillwitz, Oasis Design, *Monitoring Graywater Use, Three Case Studies in California, (n.d.)* www.water.ca.gov/wateruseefficiency/docs/monitoringGW_Use.pdf

Figure 27. Benefit – Cost analysis from three sites in California79

Graywater Test Location	Cost of Equipment	Value of Water Saved over 20 Yrs	Benefit/Cost Ratio	Payback Period (Yrs)
Santa Barbara	$1131	$893	0.79	25
Danville and Castro Valley	$5400	$895	0.17	120

Source: CA Department of Water Resources, http://www.water.ca.gov/wateruseefficiency/docs/monitoringGW_Use.pdf

Water rate increases are a matter of fact in 2012 and beyond, whether due to infrastructure upgrades, water conveyance and treatment costs, water conservation programs, and due to the increased valuation of water itself as a limited resource. As rates increase, and the costs for system installations lessen, as a natural economic evolution of wider adoption of graywater, the sensibility of graywater on a purely economic scale, will increase. Referring back to the scarcity and high-demands on water supplies in California, will encourage those not motivated by payback periods.

[79] Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

11. LAWS, CODES, ORDINANCES AND PERMITTING

Across the globe, the scope of graywater reuse varies greatly. Australia and New Zealand have been ahead of the game for years, providing the local regulations, guidance and education needed for residents to make the most of their wasted water. Mexico has begun using treated gray water for irrigation. However, in some less-developed nations, things are less encouraging. Ironically, the strict laws gray water advocates are fighting to overcome in developed nations were originally instituted to protect the environment and public health.

The United States as a whole has been slow to encourage graywater as a standard form of water conservation and groundwater recharge by defining graywater standards. States in more arid regions (such as Arizona, California, New Mexico and Texas) that experience acute pressures on water supplies tend to have the most comprehensive regulations and guidelines for graywater reuse. A number of states allow graywater systems to be installed on a case-by-case basis, but may not define specific guidelines or legal parameters for approval. Many states simply adopt Appendix C of the International Plumbing Code (ICC, 2009), which lists toilet flushing and landscape irrigation as acceptable permitted uses of graywater.

It is common belief in the field that most existing graywater systems in California are operating without a permit. In 2005, of the many systems in use, only about 200 were estimated to be operating with a permit, about 0.01% of the total. This number is quickly changing as state and local laws are changing making it easier for the SRU and MFU dwellers become acquainted with graywater to adopt direct practices, primarily through the efforts of municipalities and nonprofits.

Between 30 of the 50 states have regulations allowing, prohibiting, or regulating graywater reuse in one form or another. Several other states such as North Carolina allow graywater reuse only if it is first treated to standards identical to those required for the combined wastewater stream.[80] These laws are also in transition for the reasons previously stated.

A. Definition of Graywater in California

The importance of graywater recycling and reuse has been recognized by California's Department of Housing and Community Development which proposed the adoption of emergency graywater regulations into the 2007 California Plumbing Code. Approved by the California Building Standards Commission in August 2009,

[80] Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

the revised plumbing code adopted into law in 2010 now presents clearer and less restrictive regulations for graywater reuse.[81]

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

In February 2008, state senator Alan Lowenthal introduced SB-1258 (Building standards: graywater), which instructed the Department of Housing and Community Development to adopt revised standards for construction of systems for indoor and outdoor use of graywater. The bill was passed by the legislature and approved by the governor July 22, 2008.

In 2009, the California Department of Housing and Community Development (HCD) then initiated a consultation process with the stakeholders to develop a revised section (Chapter 16-A of the California Plumbing Code) for graywater. Based on the testimony presented at public forums and after several cycles of revisions and extensive comments, the final code language was adopted as an emergency measure by the Building Standards Commission and became effective on August 4, 2009.[82]

The Code went into effect as a permanent code in January 2010, pursuant to bi-annual updates. The code specifically states that, *a graywater system, utilizing only a single domestic clothes washing machine in a one or two family dwelling, in compliance with all of the following, may be installed or altered without a construction permit*. The specific State requirements in California for graywater systems are extracted from the 2010 California Plumbing Code and listed below:[83]

- *If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a graywater irrigation or disposal system.*
- *The design shall allow the user to direct the flow to an irrigation or disposal field, or the building sewer. The direction control of the graywater shall be clearly labeled and readily accessible to the user.*

[81] Yorum Cohen, UCLA Institute of the Environment and Sustainability, 2009, *Graywater- A Potential Source of Water*, http://www.environment.ucla.edu/reportcard/article.asp?parentid=4870
[82] Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf
[83] The Graywater Alliance, California Plumbing Code (Title 24, part 5, Chapter 16A, Part 1), (n.d.) http://www.greywateralliance.org

- *The installation, change, alteration or repair of the system does not include a potable water connection or a pump and does not affect other buildings, plumbing, electrical or mechanical components including structural features, egress, fire-life safety, sanitation, potable water supply piping or accessibility.*
- *The graywater shall be contained on the site where it is generated.*
- *Graywater shall be directed to and contained within an irrigation or disposal field.*
- *Pooling or runoff is prohibited and shall be considered a nuisance.*
- *Graywater may be released above the ground surface provided at least two (2) inches of mulch, rock, soil, or a solid shield covers the release point. Other methods that provide equivalent separation are also acceptable.*
- *Graywater systems shall be designed to minimize contact with humans and domestic pets.*
- *Water used to wash diapers or similarly soiled or infectious garments shall not be used and shall be diverted to the building sewer.*
- *Graywater shall not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.*
- *Exemption from construction permit requirements of this code shall not be deemed to grant authorization for any graywater system to be installed in a manner that violates other provisions of this code or any other laws or ordinances of the Enforcing Agency.*
- *An operation and maintenance manual shall be provided. Directions shall indicate the manual is to remain with the building throughout the life of the system and indicate that upon change of ownership or occupancy, the new owner or tenant shall be notified that the structure contains a graywater system.*
- *According to the California State Plumbing Code, California doesn't require permits for those laundry systems not altering household plumbing (often referred to as "laundry to landscape" systems, see diagram below), but does require them for other types of systems in which plumbing must be altered, such as graywater from showers, tubs, and bathroom sinks.*[84] *Most municipalities and water agencies also require backflow prevention if a pump is used to distribute the graywater or if a storage tank larger than 200 gallons is used.* [85]

The City of Berkeley's permitting chart reflects the CA Code allowances.

[84] Wholly H2O, *Graywater Codes and Regulations*, (n.d.) http://www.whollyh2o.org/graywater
[85] The City of Soquel Creek, August 17, 2010, *Greywater Rebate*, http://www.soquelcreekwater.org/content/graywater-rebate

Figure 28. Permitting Requirements from the City of Berkeley

Permitting Requirements:

System Type	Plumbing Permit	Electrical Permit	Building Permit	Zoning Requirements
Clothes Washer System	No*	No	No	None
Simple (<250 gallons)	Yes	Yes, if pump	No**	Check with Zoning
Complex (>250 gallons)	Yes	Yes, if pump	No**	Check with Zoning

*A permit shall not be required for a clothes washer system that does not cut or alter the existing plumbing piping as long as it is in compliance with the Graywater System Requirements (2007 California Plumbing Code Section 1603A.1). Clothes washer systems with a tank and/or pump will require a permit.
** If the tank height is greater than twice the width of the base and over 5000 gallons, a building permit, plans and calculations for foundation and anchoring of tank are required.

Source: City of Berkeley, Home Graywater Collection Systems, http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=45756

Given that indoor use of graywater must comply with Title 22 water standards, at this time indoor use of graywater is not practical or cost effective as retrofits. By following Tucson's example, it could become a viable source to replace some indoor water use, such as toilet flushing.

For new construction and remodels requiring permits, people usually work with their local building department to obtain a graywater permit, or install a graywater stubout to which a future graywater system can be connected after the final inspection. Arizona, Texas, and New Mexico do not require permits for residential graywater, as long as health and safety guidelines are followed.[86]

B. Snapshot of International Graywater Regulation

When considering the adoption of best practices, a survey of other best practices in cities states and countries, whether legal in the state of California or not, points us to both potentials and pitfalls. As other national and international government agencies address the growing shortfall by pressing ahead on water reuse and recycling, the state of California can take advantage of their lead and lessons learned.

Australia

In the face of extreme drought brought on by lack of precipitation combined with unusually high air temperatures during the first decade of the twenty first century, the Government of Australia has taken a necessarily strong approach to the inclusion of graywater in their national water management strategy. Given California's close relationship to drought, as a standard condition at least 1/3 of our time, Australia provides an appropriate example to follow. They have not only been aggressive in per capita water use reduction goals, but in instituting laws that require water reuse. It is instructive to note that the government itself is pushing to obviate public health concerns in their encouragement graywater use.

[86] Ibid.

Because of the long-term effects of the drought, many state governments in Australia have worked to "drought-proof" their states with more permanent solutions. Most Australian capital cities faced a major water crisis with less than 50% of water storages remaining.

Melbourne

By 2009, Melbourne had had rain up to 90% below the average during the previous 4 years, compounding the problem of extremely low rainfall combined with unusually high temperatures from the previous years.[87] Water levels in Melbourne's dams were at 27% of capacity. Their response was to create a campaign called Total Watermark – City as a Catchment, outlining the City of Melbourne's goal to become a water sensitive city.

A water sensitive city aims to protect waterways, respond to climate change and sustainably manage the total water cycle. Understanding how water flows through our municipality as well as the resulting pollutants is essential to the "city as a catchment" approach.

In addition to the commendable approach of considering an entire city as "catchment", they Included graywater harvesting in the strategies to reach these goals. Their guidelines cover SRUs, MRUs, and Commercial sectors.

This chart outlines the legal use of graywater in Melbourne:

Figure 29. Approved Uses of Graywater in Melbourne

Treatment	Appropriate use of greywater sourced from and recycled on *single domestic premises*		Appropriate use of greywater sourced from and recycled on *multi-dwelling*[2]*/commercial*[3] *premises*	
Secondary treatment (20/30 standard) (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yes[4]
	Surface irrigation	No	Surface irrigation	No
	Toilet flushing	No	Toilet flushing	No
	Washing machine	No	Washing machine	No
Secondary treatment and disinfection (20/30/10 standard) (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yes[4]
	Surface irrigation	Yes	Surface irrigation	Drip only[4]
	Toilet flushing	No	Toilet flushing	No
	Washing machine	No	Washing machine	No
Advanced secondary treatment and disinfection (10/10/10 standard)[7] (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yes[4]
	Surface irrigation	Yes	Surface irrigation	Drip only[4]
	Toilet flushing	Yes	Toilet flushing	AGWR standard only[6]
	Washing machine	Yes[5]	Washing machine	AGWR standard only[6]

Source: EPA Victoria, Code of Practice - Onsite Wastewater Management, 2008, http://www.epa.vic.gov.au/~/media/Publications/891%202.pdf

[87] Wikipedia, (n.d.), *Drought in Australia,* http://en.wikipedia.org/wiki/Drought_in_Australia

As the chart demonstrates, according to the 2008 Code *of Practice: Onsite Wastewater* Management by the Australian Office of Environmental Protection, graywater reuse is indicated for:

- *subsurface irrigation*
- *As in the rest of Australia, with proper disinfection and filtration, graywater can be used for*
- *surface drip irrigation*
- *toilet flushing*
- *clothes washing*[88]

Canberra

In April 2004, the Australian Capitol Territory (ACT) government released the Think Water, Act Water strategy to address sustainable management of the ACT's water resources. Included in the strategy are a number of initiatives aimed at achieving a 12% per person reduction in mains water use by 2013 and 25% by 2023.

A further target set by the Government is to increase the use of reclaimed water from 5% to 20% by 2013. The program literature asserts that by reusing water, it is possible to benefit from water that would otherwise be lost to us after a single use. Using domestic graywater is one way of contributing to the achievement of this reuse target.

Because graywater has already been used, it may contain substances harmful to public health and the environment. However, through your understanding of health and environmental considerations, ongoing commitment to some simple principles, and by following relevant ACT legislations, users can use graywater without compromising public health, households or the environment.[89]

Figure 30. Canberra Potential Graywater Generation

Canberra Blackwater Source				
Household sector	Indoor water usage		Greywater generated	
	Gal/Day	% Total	Gal/Day	% Total
Toilet	32	44	n/a	n/a
Kitchen	10	13	7	50
Laundry	23	32	10	120
Bathroom	35	48	14	180
Total	100	137	100	350

[88] Australian Environmental Protection Agency, September 2008, *Code of Practice: Onsite Wastewater Management*, http://www.epa.vic.gov.au/~/media/Publications/891%202.pdf

[89] Government of Australian Capitol Territory, (n.d.), *Greywater Use*, http://health.act.gov.au/publications/fact-sheets/greywater-use

Source: EPA Victoria, Code of Practice - Onsite Wastewater Management, 2008, http://www.epa.vic.gov.au/~/media/Publications/891%202.pdf

Graywater reuse in Canberra can be sourced from bathroom shower, bathtubs and sinks and from laundry water. Kitchen graywater reuse is not recommended. The guidelines indicate that graywater can be reused in

- *outdoor subsurface irrigation*
- *with proper filtration and disinfection, graywater can be used for*
- *covered drip irrigation*
- *surface irrigation*
- *toilet flushing*
- *laundry use*
- *car washing90*

New South Wales (NSW), Australia
The Department of Water and Energy (DWE) of NSW provides the guidelines for allowable reuse of graywater. Approved methods include:

1) Manual bucketing where small quantities of water are collected from either the washing machine or the shower in a bucket for reuse outside on gardens or lawns;

2) From washing machine, and bathroom sink, shower and tub for subsurface irrigation.

3) Graywater treatment systems in order to reuse treated graywater for toilet flushing and washing machines, as well as for use on gardens and lawns. Council approval and a licensed plumber is required to install the system. [91]

Western Australia
In 2010, the *Code of Practice for the Reuse of Greywater in Western Australia* was put into place. As stated, the objective of this Code is to assist in the promotion of acceptable long-term graywater reuse and promote conservation of our quality ground and surface water supplies without compromising public health. This code sets the minimum requirements for the reuse of graywater in single residential domestic premises; multiple dwellings producing up to 1320 G/day of graywater, Commercial premises reusing up to 1320 G/day.

The code indicates the benefits of graywater use in Western Australia as:

- *Reducing potable water demand*

[90] Ibid.
[91] New South Wales Government, Water for Life, *Greywater,* (n.d.) http://www.waterforlife.nsw.gov.au/recycling/greywater

- *Reducing the amount of wastewater discharged to the ocean or rivers*
- *A healthier garden, especially during drought periods*
- *Reducing household water bills.*
- *Graywater reuse is allowable for outdoor subsurface irrigation.*

With a properly installed disinfection and filtration system, graywater can be used for

- *above ground irrigation*
- *toilet flushing*
- *clothes washing*

Sydney

The Sydney water department determines that residential water use accounts for 70% of total water use. According to Sydney Water, approximately 61% of the total blackwater produced by an average household can be used as grey water. Kitchen sinks and toilets are not allowable sources of graywater collection.

Using graywater instead of our precious drinking water for outdoor purposes could save each household up to (13,208 gallons) of drinking water every year.[92]

The table below, adapted from Sydney Water, indicates the total amount of blackwater and graywater produced in in each SFU. Through graywater reuse, each household produces 11 gallons per day. [93]

Figure 31. Sydney Potential Graywater Generation

Sydney Blackwater Source				
Household sector	Total Blackwater		Total Graywater	
	Gal/Day	% Total	Gal/Day	% Total
Toilet	49	32	n/a	n/a
Hand Basin	7	5	7	8
Bath/Shower	50	33	51	54
Kitchen	12	7	n/a	n/a
Laundry	36	23	10	38
Total	155	100	94	100

Source: EPA Victoria, Code of Practice - Onsite Wastewater Management, 2008, http://www.epa.vic.gov.au/~/media/Publications/891%202.pdf

Final Sentence

[92] Sydney Water, (n.d.) *Greywater*. http://www.sydneywater.com.au/water4life/inyourhome/GreyWater/

[93] Enviro Friendly World, (n.d.) *Grey Water Reuse Systems in Australia: Grey Water Diverters*, http://www.enviro-friendly.com/greywater-systems-australia.shtml

C. National – State, County and City Codes and Ordinances

County and City Adoption of the 2009 Graywater Code in California

A push to include and advance graywater continues to rise from the local rather than the state level. As laundry-to-landscape graywater systems have become legal to install without a permit by state law, this is the system most promoted through programs, rebates and incentives. Most cities and counties in California are using the statewide code as their standard and have not adopted ordinances that further restrict use.

Most graywater advocates consider the state of Arizona's graywater Code as the most progressive in the country and a code to emulate.

State of Arizona Law Reclaimed Water General Permit for Graywater

The Arizona Department of Environmental Quality code is tiered according to the amount of amount of gallons used per day in a building. Tier 1 applies to SFU and MRU.

Tier One, General Permit outlines private residential use from SRU and MRU with water use of 400 gallons or less per day. Graywater collected from clothes washers, bathtubs, showers or bathroom sinks (but not from a kitchen sink, dishwasher or toilet) is allowable for outside subsurface irrigation, with no indoor graywater use allowed.[94] Arizona has a standardized General Permit for graywater harvesting, with compliance to the State graywater BMPs required. These BMPs are easily reached, easing the way for homeowners to utilize graywater technologies for potable water savings.

Arizona's BMP states:

- *First and foremost, avoid human contact with gray water, or soil irrigated with gray water.*
- *You may use gray water for household gardening, composting, and lawn and landscape irrigation, but use it in a way that it does not run off your own property.*
- *Do not surface irrigate any plants that produce food, except for citrus and nut trees.*
- *Use only flood or drip irrigation to water lawns and landscaping. Spraying gray water is prohibited.*
- *When determining the location for your gray water irrigation, remember that it cannot be in a wash or drainage carrying runoff.*

[94] There are, however, commercial buildings where graywater is used for toilet flushing in Arizona. Texas Water Savers V5, #1, Winter 1998Greywater Reuse Future Depends Definition and Agencie's Rulings. http://twri.tamu.edu/newsletters/texaswatersavers/tws-v5n1.pdf

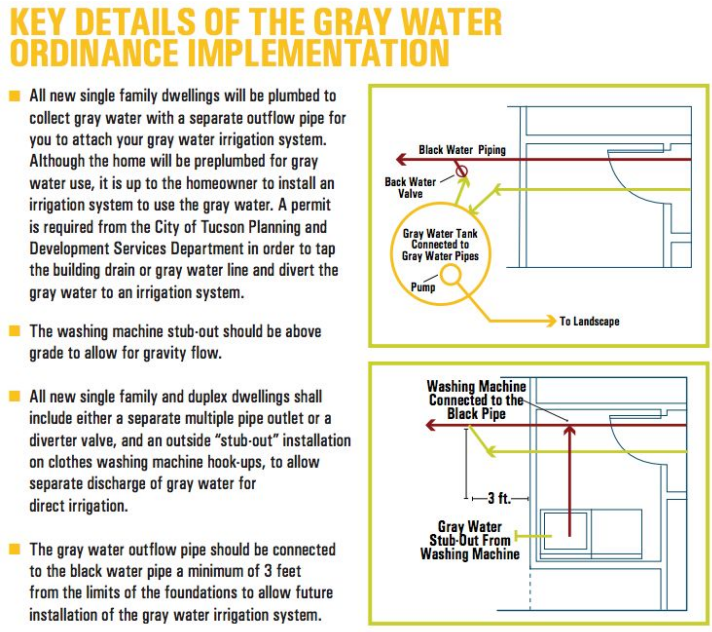
- *Gray water may only be used in locations where groundwater is at least five feet below the surface.*
- *Label pipes carrying gray water under pressure to eliminate confusion between gray water and drinking water pipes.*
- *Cover, seal and secure storage tanks to restrict access by small rodents and to control disease carrying insects such as mosquitoes.*
- *Gray water cannot contain hazardous chemicals such as antifreeze, mothballs and solvents. Do not include wash water from greasy or oily rags in your gray water.*
- *Gray water from washing diapers or other infectious garments must be discharged to a residential sewer or other wastewater facility, unless the gray water is disinfected prior to its use.*
- *Minimize surface accumulation of gray water to promote drying of soil.*
- *Filters may be used to reduce plugging and extend the gray water system's lifetime. If the gray water system becomes plugged or blocked, the gray water must be directed into your normal wastewater drain system.*
- *You may not reduce the capacity or reserve area requirements of your septic tank or other on-site wastewater disposal system because you are using gray water. 95*

Tucson's "Residential Gray Water Ordinance"
Tucson, a city with an average annual rainfall of 12 inches, whose major water supply is the Colorado River, is taking appropriate measures to safeguard it's water supply with aggressive inclusion of onsite nonpotable reuse, rainwater and graywater technologies.

In September 2008, the City of Tucson adopted *Local Ordinance 10579*, which requires new construction to include required plumbing features and stubouts that enable standardized graywater harvesting.

[95] The Arizona Department of Environmental Quality, Updated Feb, 2011, *Gray Water at Home: Arizona Department of the Environmental Quality Guide to Complying with the Type 1 General Permit*, www.azdeq.gov/environ/water/permits/download/graybro.pdf

Figure 32. Details of the Tucson Graywater Ordinance



Source: City of Tucson, Ordinance 10579, http://cms3.tucsonaz.gov/files/agdocs/20080923/sept23-08-527a.pdf

The code reads:

- *All new single family and duplex residential dwelling units shall include either a separate multiple pipe outlet or a diverter valve, and outside "stub-out" installation on clothes washing machine hook-ups, to allow separate discharge of gray water for direct irrigation.*
- *All new single family residential dwelling units shall include a building drain or drains for lavatories, showers, and bathtubs, segregated from drains for all other plumbing fixtures, and connected a minimum of three (3) feet from the limits of the foundation, to allow for future installation of a distributed gray Water system.*
- *All gray water systems shall be designed and operated according to the provisions of the applicable permit authorized by ADEQ under the Arizona Administrative Code, Title 18, Chapter 9.*[96]
- *The City of Tucson requires a permit in order to access any of these pre-plumbed sources of graywater, even those installed according to the ordinance. Tucson also provides an extremely detailed professional guide outlining the code, the sources and uses of graywater, and proper installation and maintenance instructions.*[97] *Within the guide, they set out the potential*

[96] City of Tucson, *Residential Gray Water Ordinance*, www.tucsonaz.gov/agdocs/20080923/sept23-08-527a.pdf

[97] City of Tucson, *City of Tucson Gray Water Ordinance: Professional Guide*, http://cms3.tucsonaz.gov/sites/default/files/dsd/Booklet%20final%200910_1.pdf

potable water savings through graywater use, as seen in figure. Graywater can be used for landscape irrigation only.

Oro Valley

Oro Valley Arizona considers gray water as a valuable resource as it makes "double" use of water that otherwise goes down the drain. Gray water systems divert some interior water from clothes washers, bathtubs, showers or bathroom sinks for use in outdoor irrigation. The city also estimates that the installation of a gray water system in typical residential construction can save a household 13,000 gallons of potable water per year.

Like Tucson, the town is seeking the installation of gray water plumbing to conserve water, promote the conservation of water and provide a safe method of reducing water demand.[98]

Florida

Florida has taken a varied approach towards residential graywater use. Prior to March 1, 2009 the Florida Building Code adopted the International Plumbing Code recommended uses and graywater was approved for use for flushing of conventional flush toilets and urinals and for subsurface landscape irrigation. After March 1, 2009, the Florida Building Codewas updated and specifies that graywater may only be used for flushing of toilets and urinals and any discharge from the building must be connected to a public sewer or an onsite sewage treatment and disposal system in accordance with Chapter 64E-6, Florida Administrative Code of the Florida Department of Health.[99] Landscape irrigation is no longer included as a permitted use of gray water in the Florida Building Code. All graywater systems require a permit.[100]

New Mexico

New Mexico is advancing graywater as a statewide water savings strategy. As of 2005, the state of New Mexico does not require a permit for private residential graywater systems that follow the following guidelines.

Graywater discharge of less than 250 gallons per day of private residential graywater originating from a residence for the resident's household flower gardening, composting or landscaping irrigation shall be allowed if:

- *a constructed graywater distribution system provides for overflow into the sewer system or on-site wastewater treatment and disposal system;*

[98] Town of Oro Valley, Arizona, 2009. *Ordinance (0) 09* -, http://www.orovalleyaz.gov/Assets/_assets/DIS/Conservation+and+Sustainability/Graywater+Ordinance.pdf

[99] http://www.floridabuilding.org/

[100] University of Florida, IFAS Extension, (n.d.) *Gray Water Reuse in Florida*, http://edis.ifas.ufl.edu/ae453

- *a graywater storage tank is covered to restrict access and to eliminate habitat for mosquitos or other vectors;*
- *a graywater system is sited outside of a floodway;*
- *graywater is vertically separated at least five feet above the ground water table;*
- *graywater pressure piping is clearly identified as a nonpotable water conduit;*
- *graywater is used on the site where it is generated and does not run off the property lines;*
- *graywater is discharged in a manner that minimizes the potential for contact with people or domestic pets;*
- *ponding is prohibited, discharge of graywater is managed to minimize standing water on the surface and to ensure that the hydraulic capacity of the soil is not exceeded;*
- *graywater is not sprayed;*
- *graywater is not discharged to a watercourse;*
- *graywater use within municipalities or counties complies with all applicable municipal or county ordinances enacted pursuant to Chapter 3, Article 53 NMSA 1978;*
- *graywater is not stored longer than 24 hours before being discharged;*
- *graywater use for purposes other than irrigation or composting is prohibited, unless a permit for such use is issued by the department;*
- *graywater is not used to irrigate food plants except for fruit and nut trees;*
- *graywater is discharged to a mulched surface area or to an underground irrigation system;*
- *graywater is not discharged closer than 100 feet to a watercourse or private domestic well, or closer than 200 feet to a public water supply well;*
- *graywater does not create a public nuisance;*
- *for residential units using an on-site liquid waste system for blackwater treatment and disposal, the use of a graywater system does not change the design, capacity or absorption area requirements for the on-site liquid waste system at the residential unit, and the on-site liquid waste system is designed and sized to handle the combined blackwater and graywater flow if the graywater system fails or is not fully used; and*
- *graywater does not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.*[101]

Texas Health and Safety Code Graywater Standards

[101] State of New Mexico, 2005, *Title 20, Chapter 7, Part 3, Environmental Protection, Waste Water and Supply Facilities Liquid Waste Disposal and Treatment*, http://www.nmcpr.state.nm.us/NMAC/parts/title20/20.007.0003.htm

Texas adopted legislation for the use of residential, commercial, industrial and institutional graywater in 2005, with an update in 2009. They do not address MFU in the legislation. It does, however, *encourage each builder encouraged to install plumbing in new housing in a manner that provides the capacity to collect graywater from all allowable sources; and design and install a subsurface graywater system around the foundation of new housing in a way that minimizes foundation movement or cracking.*

In Texas, (g)raywater is defined as *wastewater from clothes-washing machines, showers, bathtubs, hand-washing lavatories, and sinks that are not used for disposal of hazardous or toxic ingredients*. The term does not include wastewater that has come in contact with toilet waste; from the washing of material, including diapers, soiled with human excreta; or from sinks used for food preparation or disposal.[102]

Key elements of their law applying to residential contexts are:

An onsite gray-water system is not subject to permit or inspection if it conforms to the following guidelines:

- *Less than 400 gallons of graywater are used each day for domestic purposes.*
- *The graywater must come from a single-family dwelling.*
- *The system must be designed so that 100 percent of the graywater can be diverted to the owner's onsite wastewater treatment system through two backwater valves or backwater preventers; these connections must be located in the line between the house stub-out for the onsite wastewater treatment system and the onsite wastewater treatment system pretreatment tank.*
- *The graywater must be stored in tanks that are labeled clearly as non-potable; that have restricted access; that eliminate habitat for vectors; that can be cleaned; that meet the structural standards of the 2004 American Water Works Association (AWWA) standards.*
- *The graywater system must use piping that identifies the water as non-potable; such piping may be purple pipe, pipe painted purple or pipe taped with purple metallic tape.*
- *The graywater should not be applied at a rate that may result in ponding, pooling or runoff across property lines or onto paved surfaces.*[103]

[102] OneCle, *Texas Health & Safety Code - Section 341.039, 2012, Graywater Standards*, http://law.onecle.com/texas/health/341.039.00.html

[103] State of Texas, *Texas Health & Safety Code - Section 341.039. Graywater Standards*, 2005 and updated 2009, *http://law.onecle.com/texas/health/341.039.00.html;* http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/210f.pdf

12. WATER QUALITY ISSUES/PUBLIC HEALTH

There may be controversy and reluctance in some areas to use graywater. The most common concern is the potential health threat. However, most graywater is expected to have a low enough concentration of contaminants and disease-causing microorganisms that it can be reused in applications without biological treatment or disinfection as long as the application has a low risk of direct public contact (e.g., subsurface irrigation and toilet or urinal flushing and when storage is not required). The only form of graywater treatment typically provided in these cases is sedimentation to remove coarse solids and grit, and coarse filtration to remove hair and lint. If there is a need to store the water, a more advanced level of treatment and disinfection is required.

To date there are no documented cases of illness transmitted from graywater reuse in the Untied States,[104] with no cases reported to the Centers for Disease Control (CDC) related to graywater use,"[105] Nonetheless, more systematic research on this public health is needed to sway state and local officials, particularly those in health and building permitting departments.[106]

Let us state clearly that graywater is not safe to ingest. Proper reuse of graywater should not create health concerns to the public; however, depending on the source, graywater can include common contaminants that have the potential to cause human illness such as

- salts
- bacteria
- food
- household detergents and chemicals
- other microbes

In small amounts, urine and feces is occasionally measured in graywater that was used to wash linens and cloth diapers.[107] Fecal contamination in graywater indicates that etiological agents causing infection to humans may be present. The etiological agents include:

- bacteria
- campylobacteria

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[104]

[105] Richard J. Scholze, September 30 2011, *Graywater Application for Army Installations: Public Works Technical Bulletin: 200-1-101*, http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

[106] Bahman Sheik, 2010, WateReuse Foundation, *White Paper on Graywater*, http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/GraywaterFinal%20Report2010.pdf

[107] Greywater Action. Retrieved from http://greywateraction.org/content/health-studies-greywater

- salmonella
- viruses
- protozoas such as cryptosporidium and giarida.108

So while there is no reason for serious health concerns posed from graywater reuse, proper management of graywater systems is highly recommended. Every graywater system should include a guide to use and obvious signage to aid approriate use amognst a diverse population that may be using a single system over time. An understanding of how to design, use and maintain a graywater system is necessary, as is true with any household technology, particularly new practices.[109]

Graywater contains significant amounts of nutrients, particularly nitrogen and phosphorus and an average volume of graywater being 356 L per day will produce approximately 45 g of nitrogen and 3 g of phosphorus per day.

Figure 33. Typical composition of Graywater

Parameter	Unit	Greywater range
Suspended solids	mg/L	45–330
Turbidity	NTU	22–200
BOD_5	mg/L	90–290
Nitrite	mg/L	< 0.1–0.8
Ammonia	mg/L	< 0.1–25.4
Total Kjeldahl nitrogen	mg/L	2.1–31.5
Total phosphorus	mg/L	0.6–27.3
Sulfate	mg/L	7.9–110
pH	–	6.6–8.7
Conductivity	mS/cm	325–1140
Sodium	mg/L	29–230

Source: Jeppersen & Solley, http://www.fwr.org/wsaa/wsaa107.htm

A. Perceived Risks

Depending on what specific source of graywater is used and how it is used, the health risks of doing so will vary. In general, rinse water from the laundry constitutes a lower health risk than graywater originating from common kitchen uses that is of a higher risk. Doing one or more of the following can minimize risks:

- Do not use sprinklers to distribute graywater, as they create airborne aerosol droplets that can land on edibles

[108] World Health Organization (WHO), 2006, *Overview of graywater management: health considerations*, http://www.emro.who.int/ceha/pdf/Greywter%20English%202006.pdf

[109] Greywater Action, *Health Studies of Greywater,* (n.d.) http://greywateraction.org/content/health-studies-greywater

- Do not use allow graywater to come into contact with the edible part of a plant
- Ensure graywater runoff is eliminated
- Check soil saturation when using graywater during wet weather, as increased contamination may occur
- Use cleaning products that are environmentally friendly such as low-salt liquid products; Alternate graywater use with other sources, such as rainwater and the potable supply;
- Ensure that graywater does not pool-up by utilizing mulching drain fields, not applying to saturated soils, and applying graywater intermittently so that it properly soaks in;

To avoid contamination of the groundwater do not irrigate too close to wells. The proper distance will be regulated by state and local codes will vary.[110]

B. Real Risks

Conclusions from the October 2011 Monash five-year study research project indicate that the risks of gastrointestinal illnesses associated with household use of graywater are likely to be very low.[111]

[110] Australian Capital Territory, 2007, *Guidelines for residential properties in Canberra*, www.health.act.gov.au; Oasis Design, *Grey Water*, (n.d.) http://www.oasisdesign.net/greywater/

[111] Monash University, The University of Melbourne, 2011, *Water Quality and Research Australia, Understanding Graywater use Around the Home-Report to Participants*, www.wqra.com.au/publications/document-search/?download=256

Figure 34. U.S. Graywater Systems and Disease Potential

California Greywater Policy Data and Calculations

Oasis Design © Feb 24, 2009. Check http://oasisdesign.net/greywater/law/california/index.htm#references for updates to this spreadsheet. May be reproduced if credit and notice of reproduction are give

Datum	What	Date	Source	URL, comment
Greywater system exposure in California				
36,553,215	Population of caliornia	2007	US census bureau	http://quickfacts.census.gov/qfd/states/06000.html
13.9%	Households with greywater systems	1999	Soap and Detergent Manufacturer's Association Graywater	p. 14 http://www.sdascience.org/docs/Graywater_Habits_&
5,080,897	Greywater users	2009	Calculation; population * percent greywater users	extrapolation from 1999
2.87	People per household	2000	US census bureau	http://quickfacts.census.gov/qfd/states/06000.html
1,770,347	Greywater systems	2009	Calculation; greywater users / people per household	(this assumes the proportion of greywater use has not chan
System user years-CA		*Note: This is a back of the envelope-type calculation; the point is still valid if it is off by a factor of two or four*		
5,080,897	Greywater users	2009	from above	
10.0%	Households with greywater systems	1950	Estimate; in general, older infrastructure has more greywater use, approaching 100% with rural 70+ year old buildings	
10,586,223	Population of caliornia	1950	US Census Bureau	www.census.gov/dmd/www/resapport/states/california.pdf
1,058,622	Greywater users	1950	Calculation; population * percent greywater users	
3,069,760	Average number of greywater users	1949-2009	average of 2009 and 1950 greywater users	
60	Years from 1949-2009		calculation	
184,185,576	System-user-years of greywater exposure, not counting neighbo		caculation; average greywater users * years	
Greywater system exposure in United States				
303,824,640	Population of US	2008	CIA estimate	https://www.cia.gov/library/publications/the-world-factbook/p
7.0%	Households with greywater systems	1999	Soap and Detergent Manufacturer's Association Graywater	http://www.sdascience.org/index.php?option=com_content&
21,267,725	Greywater users	2009	Calculation; population * percent greywater users	extrapolation from 1999
2.59	People per household	2000	US census bureau	http://quickfacts.census.gov/qfd/states/06000.html
8,211,477	Greywater systems	2009	Calculation; greywater users / people per household	extrapolation from 1999
System user years-US		*Note: This is a back of the envelope-type calculation; the point is still valid if it is off by a factor of two or four*		
21,267,725	Greywater users	2009	from above	
10.0%	Households with greywater systems	1950	Estimate; in general, older infrastructure has more greywater use, approaching 100% with rural 70+ year old buildings	
152,271,417	Population of US	1950	NPG historical data	http://www.npg.org/facts/us_historical_pops.htm
15,227,142	Historic greywater users	1950	Calculation; population * percent greywater users	
18,247,433	Average number of greywater users	1949-2009	average of 2009 and 1950 greywater users	
60	Years from 1949-2009		calculation	
1,094,845,995	System-user-years of greywater exposure, not counting neighbo		caculation; average greywater users * years	
Reports of graywater-transmitted illness in US				
0	Reports of greywater-transmitted illness		18 years of greywater policy discussion, Letter from CDC	
400	People struck by lightning in the US, per year	2008	NOAA lightening safety	http://www.lightningsafety.noaa.gov/medical.htm
344	People drowned in bathtubs	2005	National saftey council	http://www.nsc.org/research/odds.aspx
Greywater system permit compliance rate in California				
1,770,347	Greywater systems	2009	from above, extrapolation from 1999	(this assumes the proportion of greywater use has not chan
200	Permitted greywater systems	1992-2009	ReWater Systems, 70±, Bill Wilson + Kevin 20±, Ted Adams, 5± Art Ludwig, 2±…rest are a guess. I'd say lower bound is
8,852	Ratio of unpermitted to permitted systems		calculation	
0.011%	Percent of permitted systems		calculation	

Reportable GW Diseases, Potential & Reported	Disease	Total Cases in 2007	Est. 60 Years Cumulative Cases	Cases Linked to Graywater
	Cholera	7	288	0
	Cryptosporidiosis	11,170	502,650	0
	E. coli, Shiga toxin-producing (STEC)	4,847	218,115	0
	Giardiasis	19,417	873,765	0
	Hepatitis A	2,979	134,055	0
	Legionellosis	2,716	122,220	0
	Salmonellosis	47,995	2,159,775	0
	Shigellosis	19,758	889,110	0
	Vibriosis (non-cholera Vibrio species infections) §	447	20,115	0
	Totals	**123,713**	**4,920,093**	**0**

Source: South African Water Research Foundation, http://www.wrc.org.za/News/Pages/Safeuseofgreywaterforurbanfoodproduction.aspx

As noted earlier, fecal matter is detected in clothes and the potential exists for infection from exposure. There has been a lot of study on how much fecal matter is in graywater using the indicator bacteria called fecal coliform bacteria; however, this indicator bacterium often reproduces in graywater and does not measure actual fecal matter. While the most widely used indicator bacteria are members of the coliform group, the enterococci, bacteriophages and spores of sulfite-reducing anaerobic bacteria are now frequently used as well. A more expensive testing alternative uses the chemical biomarker, Coprostanol, which is derived from cholesterol in the gut and does not reproduce in graywater. Study results using Coprostanol were compared to results from a study that used the fecal indicator bacteria and it was shown that the fecal indicator bacteria overestimated fecal matter levels between 100-1000 times more than Coprostanol showed. This strongly indicates that the more common use of the fecal indicator bacteria in testing could be overestimating the severity of

contamination by a wide margin.[112] This is an area of further testing that may indeed lead to more accurate data in fecal contamination of graywater.

[112] Ottoson J., Stenstrom T.A. 2003, *Faecal contamination of greywater and associated microbial risks*. Water Research 37.

13. REBATES, INCENTIVES, PROGRAMS

The state of California's recognition of the potential benefit of graywater recycling and its importance in the State's overall water plan is a key step forward. In implementing this approach, California can benefit from the experience that other countries have had with graywater recycling.

In Australia, for example, government-provided information and certification regarding commercial graywater systems is clear and posted on government web sites. In addition, detailed information is provided to the public sector on available and acceptable graywater recycling technologies and approaches.[113]

Moreover, the Australian government has established a National Rainwater and Greywater (NRG) Initiative with funding and rebates to promote efficient and safe graywater recycling and rainwater storage and is available to the entire country.[114] The NRG was launched under the larger Water for the Future initiative. Highlights of the NRG included rebates of up to $500 to households for the purchase and installation of a new rainwater tank(s) connected to the toilet and/or laundry by a licensed plumber; OR the purchase and installation of a graywater system that was installed by a licensed plumber. The NRG also offered grants to surf/life saving clubs of up to $10,000 to install rainwater tanks; to undertake larger water saving projects; or to conduct water efficiency audits.[115]

Like Australia, California can develop a more sustainable water program by increasing graywater recycling to a level at which it becomes a measurable part of the state's water portfolio. However, an effective graywater recycling program must include broad public education and participation, properly managed graywater systems, centralized recycling plants where applicable, and incentives for graywater reuse programs.[116]

A. Select Rebate Programs in California[117]

City of Santa Rosa

[113] Yorum Cohen, UCLA Institute of the Environment and Sustainability, 2009, *Graywater- A Potential Source of Water*, http://www.environment.ucla.edu/reportcard/article.asp?parentid=4870

[114] Australian Government's *National Rainwater and Greywater Initiative* (NRGI) 2009, http://www.environment.gov.au/water/policy-programs/nrgi/index.html

[115] Ibid.

[116] Yorum Cohen, UCLA Institute of the Environment and Sustainability, 2009, *Graywater- A Potential Source of Water*, http://www.environment.ucla.edu/reportcard/article.asp?parentid=4870

[117] Graywater rebate programs, like most other rebate programs, are not fixed. City and water agency programs are increasing, and established programs are expanding. Public education is one of the most crucial parts of these programs, however funding generally does not support sufficient public outreach and education to accompany these rebates in California.

Santa Rosa has been a leader on developing standards and programs for graywater. Rather than a stand-alone approach, Santa Rosa includes graywater ion a larger portfolio of water conservation and localized on-site reuse. Their outreach program is an integrated part of their overall water management strategy.

Santa Rosa has developed a program brochure, a simple checklist, a sample homeowners guide, a tenant permission form and a land owner permission form.[118] Municipal water agency staff are trained to teach workshops themselves, and on-going classes are offered in both English and Spanish, targeting a wide scope of landscapers and home owners.

As of 2012, there are two options for the graywater rebate in Santa Rosa:

- *a per fixture rebate at $75 per qualifying fixture that reroutes graywater. The single-fixture or laundry-to-landscape system is the most common system that qualifies for this option.*
- *a sustained reduction rebate at $200 for every 1,000 gallons of sustained reduction in monthly water consumption. The rebate amount cannot exceed the cost of the system, excluding labor. This option is typically used for engineered graywater systems.*[119]

City of San Francisco/San Francisco Public Utility Commission

San Francisco Public Utilities Commission (SFPUC) has sought to integrate graywater as a part of their goal to reduce water use and increase water reuse.

Graywater projects that require a permit from the Department of Building Inspection (required for all other graywater systems except laundry-to-landscape), SFPUC offers a rebate up to $225 towards the cost of a graywater permit. The permit rebate will help cover the cost of obtaining a permit from the Department of Building Inspection for your site-specific graywater system. The rebate is available for residential graywater systems with subsurface irrigation.[120]

Soquel Creek Water District

As of July 2010, Soquel Creek Water District began offering a $75 rebate or each qualified graywater system installed for up to three connections for a maximum rebate of $225. The three types of connections eligible for rebates include:

- *clothes washing machine or "laundry to landscape" - $75;*
- *bathtub and/or shower - $75;*

[118] City of Santa Rosa, *Graywater Rebate Program*, (n.d.) http://ci.santa-rosa.ca.us/departments/utilities/conserve/Pages/Graywater.aspx

[119] Ibid, *Graywater Rebate Program*, (n.d.) http://ci.santa-rosa.ca.us/departments/utilities/conserve/Pages/Graywater.aspx

[120] San Francisco Public Utility Commission, *Graywater* (n.d.) http://sfwater.org/index.aspx?page=445

- *bathroom sink - $75.*

These rebates are specifically for graywater used in the landscape and do not apply to toilet flushing.[121]

B. The State of Arizona

As of January 1, 2007, Arizona taxpayers installing a "water conservation system" defined as a system credit to collect rainwater or residential graywater) in a residence are eligible for a one-time tax credit of 25% of the system cost, up to a maximum of $1000. Builders are also directly eligible for an income tax credit of up to $200 per residence unit constructed with a water conservation system installed.[122] This assists builders in reaching the target goals of Arizona's new construction code, which requires water reuse drains and stub-outs be included.

The total amount of the credit that was available to all Arizona individual taxpayers was limited to $250,000 per year and only one credit in a tax year is allowed per residence. Tax credits claimed over multiple years by a taxpayer for the same residence were not to exceed $1000. For corporate tax credits, the total amount available was limited to $500,000 per year.[123]

Tucson's Rebate

Tucson encourages compliance with their local building code requiring new construction to include drains and stub-outs for water reuse. Tucson Water's Single Family Residential Gray Water Rebate Program reimburses 1/3 of system installation costs up to $200 when a permanent gray water irrigation system is installed in a residence. It covers both materials and labor. These systems are designed for landscape irrigation only.

The Program outlines:

- *The installation residence must be located within Tucson Water's service area.*
- *Rebates are available for retrofitting existing homes, as well as connecting new homes to gray water irrigation systems.*
- *The system must be permanent.*
- *A permit may be required.*
- *Rebate applications must be complete and are subject to verification and fund availability.*

[121] Soquel Creek Water District, *Graywater Rebate*. (n.d.) http://www.soquelcreekwater.org/content/graywater-rebate

[122] Brad Lancaster, Rainwater Harvesting for Drylands and Beyond, *Water Harvesting Financial Incentives and Tax Credits,* (n.d.) http://www.harvestingrainwater.com/greywater-harvesting/greywater-and-rainwater-harvesting-financial-incentivestax-rebates/

[123] State of Arizona, *Arizona Graywater Conservation Tax Credit for Gray Water*, (n.d.) http://cms3.tucsonaz.gov/water/aztaxcredit

- *Applicant must attend a two-hour workshop covering best practices.*
- *Rebate funds are limited and will be distributed on a first come, first served basis.*
- *The Rules:*
- *Gray water may be used to irrigate by flooding, through underground pipes or a drip system.*
- *Do not spray irrigate with gray water.*
- *Don't let it run off – gray water must be used on your property.*
- *Gray water may be used for household gardening, composting, lawn watering and landscape watering.*
- *Surface watering of gray water may not be used to irrigate food plants, except for citrus and nut trees.*
- *Avoid detergents that contain boron or are high in salts. They are toxic to plants.*
- *Water from softening systems that use sodium chloride should not be used for gray water. The salt from this type of water softening will harm plants.*

14. GREEN BUILDING STANDARDS: LEED, CALGREEN, EPA WATERSENSE

A. CALGreen

The California Green Building Standards Code (CALGreen) is the first statewide green building code in the country and seeks to establish minimum green building standards for the majority of residential and commercial new construction projects across California. The 2010 California Green Building Standards Code, or CALGreen, is now mandatory, effective as of Jan. 1, 2011. California is the first state to adopt a green building code that imposes energy efficiency and other green standards on new construction in an effort to achieve reductions in natural resource consumption and greenhouse gas emissions. Despite its first-in-the-nation status, CALGreen represents only a modest change from prior California green building requirements.

CALGreen establishes minimum uniform standards for green building that apply to many types of new construction, including commercial, low-rise residential, state owned and educational buildings. Cities and counties were required to draft and approve ordinances to adopt CALGreen by Jan. 1.

CALGreen was developed by the California Building Standards Commission, the state agency charged with developing and adopting building standards and codes, in response to California's Global Warming Solutions Act or AB 32. The Act requires a reduction of greenhouse gas emissions levels to those found in the year 1990 by 2020. Following passage of the Act in 2006, state legislators focused on buildings, which are the second largest contributor to greenhouse gas emissions at 24 percent, and introduced several bills containing potentially inconsistent and unrealistic green building standards.

The commission determined that although some cities had implemented green building provisions, the local green building codes were based on different standards, creating inconsistencies from city to city.

In response, the commission sought to set minimum uniform standards. It solicited input from the building industry including the American Architects Association, the Building Industry Association, the International Council of Shopping Centers, the National Association of Industrial and Office Parks, and the California Business Properties Association, as well as state agencies, such as the California Energy Commission, the Air Resources Board, the Department of Water Resources, the Department of General Services, and California Department of Resources Recycling and Recovery. The commission also reviewed LEED and other green building rating systems.

CALGreen encompasses residential and non-residential mandatory measures. The non-residential mandatory measures are classified into the following categories: Planning and Design; Energy Efficiency; Water Efficiency and Conservation; Material Conservation and Resource Efficiency; and Environmental Quality.

In many cases, CALGreen merely adopts existing state requirements. For example, it does not impose any new energy efficiency standards. Buildings are merely required to comply with the California Energy Commission's existing Title 24 requirements. However, the commissioning requirement is new: a third party must review, test and adjust building design, construction and operation systems to ensure that the components perform according to the developer's requirements.

CALGreen permits local jurisdictions to adopt codes with requirements that exceed the minimum standards. In addition, CALGreen includes two sets of voluntary provisions referred to as Tier 1 and Tier 2 to encourage communities to take further action. Examples of the Tier 1 voluntary measures include exceeding energy efficiency by 15 percent, achieving 30 percent water savings, reducing construction waste by 65 percent, using up to 10 percent recycled materials, and designating 10 percent of parking spaces for fuel-efficient vehicles.

The Tier 2 voluntary measures are even "greener." Tier 2 voluntary measures include exceeding energy efficiency by 30 percent, achieving 35 percent of water savings, reducing construction waste by 80 percent, using 15 percent recycled materials, and designating 12 percent of parking spaces for fuel efficient vehicles. Tier 2 also contains a solar reflectance index standard for "cool" roofs.

1. a) Worksheets

Water Use Calculation Forms (Section 4.303)

WS 1 – Baseline Water Use: http://www.hcd.ca.gov/codes/calgreen/WS-1.pdf

WS 2 – 20 Percent Reduction Water Use Calculation Table: http://www.hcd.ca.gov/codes/calgreen/WS-2.pdf

- *Provide water efficient landscape irrigation design that eliminates the use of potable water beyond the initial requirements for plant installation and establishment. There is a list of 6 different methods that include plant coefficient, irrigation efficiency and distribution uniformity, use of captured rainwater, use of recycled water, use of graywater, etc.*
- *Restore all landscape areas disturbed during construction by planting with local adaptive and/or non-invasive vegetation.*
- *On previously developed or graded sites, restore or protect at least 50% of the site area with adaptive and/or non-invasive vegetation.*

- *Install a graywater collection system for onsite subsurface irrigation per Appendix G, 2007 California Plumbing Code.*

With respect to water use efficiency, CALGreen has mandatory and voluntary measures for residential and non-residential buildings. The goal of indoor residential measures is to reduce potable water consumption by 20%. Mandating the maximum allowable water use per plumbing fixture does this, e.g., 1.6 gallons per flush toilets or 2.5 gallons per minute for a showerhead. For outdoor water use automatic irrigation controllers must be weather or soil-moisture based that automatically adjust irrigation in response to changes in plants' needs as weather conditions change. Voluntary measures include water efficient clothes and dishwashers and outdoor drip irrigation.

For non-residential building, the mandatory building code is clear: add more meters (aka sub-meters) to measure irrigation use, building use, and so on. Use of graywater and recycled water is also recommended plus measures to reduce blackwater production. Voluntary measures include using native plants.

However CALGreen does not address two key "fixes" that can significantly reduce water waste: improving plumbing and automatic water monitoring. We are all aware of the amount of water we waste everyday waiting for it to heat up. Let's fix that by mandating building codes that require plumbing upgrades for new buildings that eliminate this huge source of unnecessary waste. Automatic water monitoring identifies leaks and provides insight into water usage and opportunities for conservation. Cost effective and non-disruptive water automation is now finally available (Aquacue Barnacle). Let's start using this technology to reduce water waste.

The Department of Water Resources and the Department of Housing and Community Development regulate Graywater systems in California. Building codes in the state of California vary depending on different types of construction from residential to commercial. The California building standards codes are set forth under the CALGreen state program by the California Building Standards Commission (CBSC).

With regards to graywater regulations and codes, the CALGreen 2010 report states that non-residential buildings are required to reduce wastewater by 20% and approved graywater systems are suggested in order to achieve this. With respect to residential water use, graywater is approved as an irrigation method in order to either reduce or eliminate potable water use.[124]

[124] California Green Building Standards Code, *California Code of Regulations Title 24, Part 11*, 2010, http://www.documents.dgs.ca.gov/bsc/calgreen/2010_ca_green_bldg.pdf

B. LEED

The United States Green Building Council (USGBC) provides rating systems for new home construction, current buildings, commercial buildings, schools, retail, etc. These ratings are set forth by the LEED certification system and codes for graywater regulate what must be done in order for a building to receive LEED certification. Graywater systems are included on the "LEED for homes" checklist under the water reuse section; however, this kind of reuse system garners the lowest point total among the three approved reuse systems. Rainwater harvesting and using municipally recycled water score the highest in the water reuse section of the LEED checklist.[125]

LEED rating systems indicate that a graywater system must include a tank or dosing basin that can be used as part of the irrigation system. Graywater must be collected from at least one of the following: clothes washer, showers, or some combination of faucets and other sources estimated to exceed 5,000 gallons per year. Furthermore, a graywater reuse system should be integrated with resource-efficient landscape and irrigation system design. If a home is already using a municipal recycled water system, the home can have but cannot receive points for a graywater reuse system.[126]

LEED rating systems also offer points if education on operation and maintenance of installed graywater systems is provided to the homeowner or tenant. This is also true should education be offered to the building manager.[127]

On average, a LEED certified building uses 30% less water than a conventional building, which translates to more than 1 million gallons of water saved per year. Reducing the amount of water that needs to be conveyed to and treated by municipal wastewater treatment facilities also reduces pumping and process energy required to these systems. LEED, through practices like rainwater harvesting, promotes on-site storage and use of rainwater and graywater to lower water consumption cost, and it reduces the impact on storm drainage and municipal treatment systems. Specifically, water harvesting efforts can earn a significant number of LEED points across several categories:

LEED Points for Water Harvesting Efforts

- *Stormwater Design: Quantity Control - 1 point (SS Credit 6.1)*
  Reduce impervious cover, increase on-site infiltration, reduce pollution from stormwater runoff by eliminating contaminants

[125] U.S. Green Building Council, 2008, *LEED for Homes Rating System*, http://www.usgbc.org/ShowFile.aspx?DocumentID=3638
[126] Ibid.
[127] Ibid.

- *Stormwater Design: Quality Control - 1 point. (SS Credit 6.2)*
  Storm water treatment systems designed to remove 80% of the average annual post-development total suspended solids using rainwater recycling, vegetated roofs and swales, pervious pavement.
- *Water Use Reduction: 20% Reduction - 1 point. (WE Credit Prerequisite 1)*
  20% reduction in water use for building using alternative on-site sources of water such as rainwater, stormwater and graywater
- *Water Efficient Landscaping, Reduce by 50% - 2 points. (WE Credit 1.1) Limit or eliminate the use of potable water for landscape irrigation by using captured rainwater, recycled wastewater, groundwater and other means.*
- *Water Efficient Landscaping, No Potable Water Use or No Irrigation - 2 points in addition to WE Credit 1.1. (WE Credit 1.2)*
  Use only captured rainwater, recycled wastewater or recycled graywater for site irrigation.
- *Innovative Wastewater Technologies – 2 points (WE Credit 2)*
  Reduce generation of wastewater & potable water demand, while increasing the local aquifer recharge – use captured rainwater or recycled graywater to flush toilets and urinals or treat 50% of wastewater on-site to tertiary standards.
- *Water Use Reduction, 30% - 40% reduction – 2-4 points (WE Credit 3)*
  Maximize water efficiency within building to reduce the burden on municipal water supply & wastewater systems. Use alternative on-site sources of water such as rainwater, stormwater and graywater for non-potable applications such as toilet flushing and urinal flushing.
- *Innovation Design Credit - 1 point (ID Credit 1-1.5)*
  Projects that result in exceptional performance above the requirement set by LEED.

C. EPA WaterSense

The EPA WaterSense partnership program discusses federal ratings standards for graywater. EPA WaterSense recognizes that the National Science Foundation (NSF) International has established a wastewater treatment task group for onsite residential and commercial graywater treatment systems. The NSF drafted a new standard, NSF 350 - Onsite Residential and Commercial Reuse Treatment Systems, which encompasses residential wastewater treatment systems along with systems that treat only the graywater portion. The EPA and CDC assembled experts to explore the science available for addressing high-priority regional needs such as graywater risk to humans and ecosystems and risk management options for graywater.[128]

[128] U.S. Environmental Protection Agency Municipal Support Division Office of Wastewater Management. 2004, *Guidelines for Water Reuse*, http://www.epa.gov/nrmrl/pubs/625r04108/625r04108.pdf