Queensland Government
Natural Resources and Mines

ON-SITE SEWERAGE FACILITIES

GUIDELINES
For the
USE AND DISPOSAL OF GREYWATER
IN UNSEWERED AREAS

TO BE READ IN CONJUNCTION WITH THE "ON-SITE SEWERAGE CODE"

June 2003

FORWARD

As clean water resources become more valuable the concept of separating out the greywater from the home's waste stream and using it to supplement the family's water demand is becoming increasingly appealing. Many questions arise when the subject of reusing greywater comes up. The objectives of these guidelines are to assist in the promotion of acceptable greywater reuse practices and to ensure conservation of our quality ground and surface water supplies.

They provide acceptable solutions for greywater reuse in unsewered areas in accordance with the requirements of the "On-site Sewerage Code".

Further information on on-site sewerage systems is available on the Department of Natural Resources & Mines website at www.nrm.qld.gov.au/compliance/wic/onsite_sewerage.html or by writing to:

Water Industry Compliance
Department of Natural Resources & Mines
GPO Box 2454
Brisbane QLD 4001

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1 GENERAL

1.1 What is Greywater?

The precise definition of greywater differs in the various published codes and guidelines however the definition in the Australian/New Zealand Standard™ AS/NZS 1547:2000 "On-site Domestic-wastewater Management" is:

> "*The domestic wastes from baths, showers, basins, laundries and kitchens specifically excluding water closet and urinal waste. Greywater does not normally contain human waste unless laundry tubs or basins are used to rinse soiled clothing or baby's napkins.*"

Greywater is therefore the components of domestic sewage that have not originated from the toilet.

1.2 Purpose of Guideline

Increasing pressure is being placed on the community to conserve water usage in the home. This pressure, combined with increasing interest in water conservation has prompted many enquiries about reusing greywater. Opportunities exist to reuse greywater for garden watering, landscape watering and lawn irrigation. This will reduce the demand on potable water supplies such as rainwater tanks, surface water supplies and groundwater.

The purpose of this guideline is to provide guidance to local government officers, homeowners, site and soil evaluators, designers, installers and service technicians on the planning, designing, installing and maintaining a greywater reuse facility in an unsewered area.

The focus of the guideline is the facilitating of on-site sustainable irrigation of greywater without compromising public health and to maintain and enhance the quality of the environment. Greywater can be used in a beneficial manner for landscaping (ie. to the plant root zone) rather than simply disposal at depth, which does not benefit landscaping.

1.3 Application

Current State legislation only allows greywater reuse in unsewered areas in accordance with the requirements of the *Standard Sewerage Law 1998*[1] provisions for on-site sewerage facilities and the On-site Sewerage Code.

Under the *Standard Sewerage Law 1998*[2] and the Environmental Protection Act and its subordinate legislation greywater is a wastewater. The requirements for treatment and land application of greywater are the same as for wastewater therefore the requirements of the On-site Sewerage Code apply to greywater.

The On-site Sewerage Code permits the segregation of wastewater at the source into two separate streams i.e. blackwater and greywater.

[1] The provisions of the *Standard Sewerage Law 1998* will be replaced by equal provisions under the *Plumbing and Drainage Act 2002* at a date to be determined in 2003.
[2] Standard Sewerage Law 1998, Section 92, Disposal of Sewage Other Than Human Wastes.

In sewered areas greywater reuse is currently prohibited, as all wastewater must be discharged to sewer (Section 824 (5) of the *Water Act 2000*). The Government is currently reviewing its policy and legislation on this matter. If there is change in policy, separate guidelines will be issued for reuse in sewered areas.

1.4 Scope of Guideline

This guideline provides acceptable solutions for reuse of greywater in unsewered areas that satisfy the performance objectives, performance requirements and the performance criteria given in the On-site Sewerage Code.

This guideline applies to the reuse of greywater for garden watering, landscape watering and lawn irrigation. This guideline considers reuse of greywater in residential premises, but its general principles may be applied and utilised for other developments generating greywater. It outlines the regulatory requirements, health and environmental risks and risk minimisation procedures but it does not present detailed design procedures – it is not a design manual.

This guideline does not include the use of greywater for purposes such as toilet flushing; car washing or washing paved areas.

1.5 Definitions

All terms have the same meaning as given in the On-site Sewerage Code and AS/NZS 1547:2000. The following definitions apply to terms used in this Guideline.

Biochemical oxygen demand (BOD):- A measure of the amount of oxygen used in the biochemical oxidation of organic matter, over a given time and at a given temperature; it is determined entirely by the availability of the material as a biological food and by the amount of oxygen used by the micoorganisms during oxidation.

BOD_5:- BOD determined by standard test (5 days at 20^0C).

Blackwater:- Wastes discharged from the human body either direct to a composting toilet or through a water closet (flush toilet) and/or urinal.

Effluent:- Sewage, water or other liquid partially or completely treated or in its natural state flowing out of a septic tank, aerated wastewater treatment system, sand filter or other treatment system or treatment component.

Greywater facility:- Consists of the greywater diversion, treatment, storage and distribution equipment that recycles treated greywater to the land application area.

Primary treatment system:- These systems use coarse screen filters to remove lint, hair and coarse particles prior to subsurface discharge to the land application area.

Secondary treatment system:- These systems treat greywater to 20 mg/L BOD_5, 30 mg/L TSS standard or better prior to discharge to the land application area.

Sewage:- The wastewater from the community, including all faecal matter, urine, household and commercial wastewater that contains human waste

Total suspended solids (TSS):- The portion of total solids retained on a filter with a specified pore size, measured after being dried at a specified temperature. The specified filter is a glass fibre filter; nominal pore size 2 microns and the specified temperature 103 to 105^0C.

Treated greywater:- Greywater that has been treated to primary or secondary standard.

2 SOURCES AND CHARACTERISTICS OF GREYWATER

2.1 Sources of Greywater

As previously defined, greywater is that proportion of untreated household wastewater that has not come into contact with toilet water. Greywater can be simply separated from household wastewater by having separate household plumbing systems for greywater and blackwater as depicted in Figure 1.

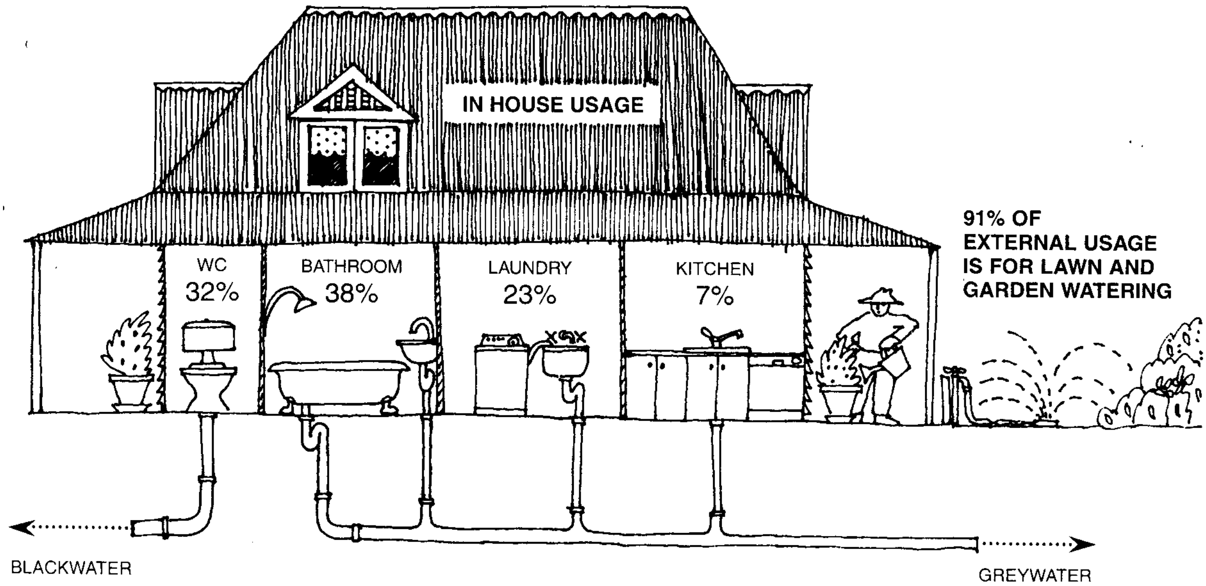


Figure 1 – Potential Sources of Greywater and In House Usage of Water *(Source Jeppersen and Solley, 1994)*

Potential greywater sources include:

- Bathroom shower, bath and basin
- Laundry tubs and clothes washing machine,
- Kitchen sink and dishwasher.

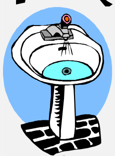
The choice of what is an acceptable greywater source in the home depends on the type of greywater facility to be installed and the method of reuse. This is because each greywater source has different physical, chemical and microbiological qualities.

2.2 Source Volumes of Greywater

The volumes of greywater available at any particular house vary depending on number of occupants, number and age of children, personal habits and lifestyles. The average volumes of wastewater generated from each source in a three-bedroom home are presented in Table 1. From this table it can be seen that there is approximately 400 litres per day of greywater available for recycling from a three-bedroom dwelling.

The greywater volumes in Table 1 do not take into account water conservation devices, such as low volume shower roses or dual flush toilets. Consequently, the volume of greywater available for use may be less than given in Table 1. A method of estimating the greywater flow is given in Appendix 1.

Table 1 Total In-house Water Usage – Brisbane

	Source	*Average Volume Litres/dwelling/day*	*Percent of Total*
	Laundry	135	23
	Shower/bath	193	33
	Basin	28	5
	Toilet	186	32
	Kitchen	44	7
	Total indoor water use	586	
		From Jeppersen & Solley 1994	

2.3 Greywater Characteristics[3]

The characteristics of greywater generated by a household will vary also according to the dynamics of the household and is again influenced by the number of occupants, the age distribution of the occupants, their lifestyle characteristics and water usage patterns. Water is used as a medium to dilute and convey waste away from the occupants on the inside of the building and to flush the household plumbing fittings. Wastewater may have become contaminated in three ways due to the addition of waste material:

- The water is **contaminated by microorganisms**, many of which may be pathogenic, i.e. cause disease;
- The water may be **polluted chemically** by dissolved salts such as sodium, nitrogen, phosphates and chloride or by organic chemicals such as oils, fats, milk, soap and detergents which may provide food for microorganisms and plant growth; and
- The water may be **physically polluted** by particles of dirt, food, lint, sand etc.

[3] Adapted from NSW Health, "Greywater Reuse in Sewered Single Domestic Premises" April 2000 and Department of Primary Industries Qld "Policy Options Paper - The Use of Greywater" January 1996.

The characteristics of greywater from each source are summarised in Table 2.

Table 2
Summary of Untreated Greywater Characteristics from each Source

Water Source	Characteristics
Laundry	*Microbiological*: variable thermotolerant coliform loads, depending on dwelling occupancy i.e. family with children. Wash water has poorer microbial quality than rinse water. *Chemical*: sodium, phosphate, boron, surfactants, ammonia and nitrogen from soap powders and soiled clothes, *Physical*: high in suspended solids, lint and turbidity, *Biological:* high in biochemical oxygen demand.
Bathroom	*Microbiological:* variable levels of thermotolerant coliforms, poorer microbial quality than laundry rinse water. *Chemical:* soap, shampoo, hair dyes, toothpaste and cleaning chemicals, *Physical:* high in suspended solids, hair, and turbidity, *Biological:* lower levels of concentrations of biochemical oxygen demand.
Kitchen	*Microbiological:* variable thermotolerant coliform loads, *Chemical:* detergents, cleaning agents; *Physical:* food particles, oils, fats, grease, turbidity *Biological:* high in biochemical oxygen demand.

2.3.1 How is Faecal Contamination Measured?

Thermotolerant coliforms are also known as faecal coliforms and are a type of microorganism that typically grow in the intestines of warm blooded animals (including humans) and are shed in their millions to billions per gram of faeces. When thermotolerant coliforms are detected in water, by a sample taken for laboratory analysis, it indicates recent faecal contamination from animals. In the case of greywater derived from a household wastewater system, the presence and elevated numbers of thermotolerant coliforms indicates the likely presence of human faeces and is therefore a gauge of the possible presence of pathogenic microorganisms. An absence of thermotolerant coliforms however, does not necessarily mean an absence of pathogenic microorganisms as there may be pathogenic organisms present that are not associated with faecal material e.g. food spoilage and food poisoning microorganisms.

Thermotolerant coliforms are usually expressed as organisms per 100 millilitres – org/100 mL, or colony forming units per 100 millilitres – cfu/100mL. It is useful to bear in mind while reading this guideline that typical thermotolerant coliforms found in raw sewage are in the order of 10^6 to 10^8 org/100 mL and from 10^6 to 10^{10} org/100mL in septic tank effluent. (NOTE: 10^6 to 10^8 means 1,000,000 to 100,000,000)

2.3.2 Laundry Greywater

Laundry wastewater represents about 23% of household wastewater (35% of greywater). Greywater from the laundry improves in quality from wash water to first rinse water to second rinse water. Microbiologically, thermotolerant coliforms vary from 10^7org/100 mL when nappies are washed to 25 org/100 mL for second rinse water. The detergents used in clothes washing give rise to the presence of phosphorus, ammonia, organic nitrogen and boron in varying amounts depending on the product and suspended solids such as lint, hair and dirt. Many of these contaminants are classified as nutrients and if transferred to waterways or groundwater may lead to environmental damage.

First and second rinse laundry greywater still contain a pollutant load and still pose a threat to public health, although greatly reduced. Also the laundry tub is often used to irresponsibly and illegally to dispose of harmful substances such as paints, solvents, pesticide and herbicide residues further increasing the pollutant potential. Domestic pets, which may often be washed in the laundry tub, are a further source of contamination.

2.3.3 Bathroom

The bathroom (hand basin, shower and bath) generates about 38% of the household wastewater flow (55% of greywater) and is considered to be the least contaminated type of greywater. Microbiologically, thermotolerant coliform concentrations have been assessed in shower and bath water to be in the range of 10^4 to 10^6 org/100 mL. As people often urinate in showers and baths concern is often expressed about the increased health aspects of inappropriate disposal. While urine in a healthy person is sterile, some bladder infections may pass microorganisms in urine. However, the potential for these organisms to survive and cause infection is considered remote. The ammonia in urine is beneficial to plants but may harm the environment if not adequately dispersed. Wastewater from hand basins is more polluted than bath or shower wastewater.

Soap is the most common chemical contaminant found in bathroom greywater and other common contaminants are hair shampoo, hair dyes, toothpastes and cleaning chemicals. Hair is of particular concern in regard to clogging of pipes and irrigation outlets. Biocidal soaps have little effect on reducing the bacterial load in greywater.

2.3.4 Kitchen

Kitchen wastewater is heavily polluted physically with food particles, oils, fats and other highly polluting waste and is often more polluted than blackwater or raw sewage. It readily promotes and supports the growth of microorganisms. Because of the solid food particles and because fats can solidify, kitchen wastewater may cause blockages in land application systems unless the fats are treated or removed from greywater.

Microbiologically, high concentrations of thermotolerant coliforms ($2x10^9$ cfu/100 mL) have been found in kitchen greywater but the more usual concentrations appear to be in the range of less than 10 to 10^6 cfu/100 mL. The high thermotolerant coliform concentrations sometimes found in kitchen greywater is cause for concern and must be managed effectively to prevent disease transmission.

Kitchen greywater is chemically polluted as it contains detergents and cleaning agents and where dishwashers are used the greywater is very alkaline from the detergent. The contaminants are not diluted with large volumes of water so kitchen greywater may be harmful to soils, plants and groundwater if applied directly.

It is for these reasons of health and environmental risk that kitchen greywater is not recommended for recycling and should be diverted to the facility that treats the blackwater. However, where kitchen water is a component of the greywater, it must be treated to remove solid food particles, fats and grease.

2.3.5 Swimming Pool and Spa Pool Backwash Water

Swimming pool backwash water is highly concentrated in microorganisms, chemicals (such as body oils and cosmetics) and particulates such as powder residue, hair, lint and pool chemical residues. The amount of backwash water is difficult to estimate and is variable depending on the size of the pool, filter type and usage patterns. Mainly, because of the large surge volume, swimming pool backwash water is **not normally used in greywater recycling**.

2.3.6 Comparison with Raw Sewage and Blackwater

Raw sewage, blackwater and septic tank effluent are all forms of effluent that are directly and grossly contaminated with human excrement and therefore represent a public health threat. Sewage, blackwater and septic tank effluent are all managed by high level treatment before being released into the environment above ground level and must at least be settled or filtered to remove solid particles before management by sub-soil land application area.

Raw sewage is usually directed, in metropolitan and urban areas, to a centralised sewage treatment plant for treatment and utilisation or disposal. Septic tank effluent is sewage that has been stored in a large vessel or tank and has turned septic, i.e. all the oxygen in solution has been consumed by the decaying process and the septic tank effluent becomes offensively smelly.

The chemical and physical quality of greywater compared with raw sewage is shown in Table 3.

Table 3
Comparison of Physical, Chemical and Microbiological Parameters of Untreated Greywater with Raw Sewage

Parameter	Unit	Greywater#	Raw Sewage*
pH		6.6-9.2	6.5-9.2
Turbidity	NTU	22 - >200	N.A.
Suspended solids	mg/L	45-330	100-350
Biochemical oxygen demand (BOD_5)	mg/L	90-290	100-400
Nitrogen (Total as N)	mg/L	3-57	20-85
Organic nitrogen (as N)	mg/L	2-31	8-35
Ammonia-nitrogen (as N)	mg/L	1-25	12-50
Nitrite-nitrogen (as N)	mg/L	<0.1	0
Nitrate-nitrogen (as N)	mg/L	<0.1-0.8	0
Total phosphorus	mg/L	0.6-27	5-30
Conductivity	µS/cm	325-1140	300-800
Faecal Coliform	org/100ml	10^4 - 10^6	10^7 - 10^{10}

#Adapted from Jeppersen and Solly 1994.
*Adapted from Crites and Tchobanoglous, 1998

The results in Table 3 indicate that:

- Greywater contains variable concentrations of nitrogen and phosphorus indicating that greywater may be a source of nutrients when used for lawn and garden watering;

- Because blackwater (faecal matter) is excluded from greywater there is a decreased load of faecal pathogenic organisms in the greywater.

3 THE LOCAL GOVERNMENT APPROVAL PROCESS

The legislative requirements for on-site sewage treatment and land application of the effluent are contained in the *Standard Sewerage Law 1998*[4], the subordinate legislation made under the *Sewerage and Water Supply Act 1949*. As greywater is a component of sewage the rules governing sewage also apply to greywater.

The *Standard Sewerage Law 1998* requires that an approval be obtained from the local government to install an on-site sewage facility or to change or take away an on-site sewage facility from the premises. This approval must be obtained before commencement of the work. Check with your local government for information on their process for obtaining an approval and any requirements of the local government.

This guideline compliments the "On-site Sewerage Code" and compliance with this Code is a requirement of the *Standard Sewerage Law 1998*. The "On-site Sewerage Code" may be downloaded from the Department of Natural Resources & Mines website.

[4] The on-site sewerage facility provisions in the *Standard Sewerage Law 1998* will be replaced by equivalent provisions in the *Plumbing and Drainage Act 2002* on commencement of this Act.

4 HEALTH AND ENVIRONMENTAL RISKS

4.1 Presence of Pathogenic Microorganisms

Greywater may be contaminated with microorganisms such as bacteria, viruses and protozoa. It is these microorganisms, many of which may cause disease, that present the greatest health concern associated with greywater recycling and disposal. While many bacteria cannot survive in a hostile environment like soil, some bacteria and viruses that cause disease are resilient and can often survive for long periods of time in this environment.

Disease transmission is principally through the faecal-oral route where the greywater may be directly ingested through contaminated hands or indirectly ingested through contact with contaminated items such as grass, soil, toys, garden implements and treatment plants while they are being serviced. Transmission may also occur through inhalation of irrigated spray, by penetration through broken skin, and by insect vectors such as flies and cockroaches. Contaminated drinking water aquifers may facilitate ingestion of pathogens.

4.1.1 Minimising The Health Risk

The health risk posed by recycling untreated greywater can never be eliminated, however it can be minimised by appropriate treatment, careful management and responsible use. This may be achieved by:

- separating potentially contaminated nappies and clothes;
- never drinking greywater or allowing pets or animals to drink or have access to it;
- ensuring greywater does not contaminate any source of drinking water: e.g. drinking water aquifer;
- applying greywater to the garden by subsurface irrigation. This will reduce human exposure to the water;
- not irrigating vegetable gardens supplying food crops that are eaten raw or undercooked as this would pose an unacceptable health risk.;
- not allowing greywater to pool or stagnate as this will attract insects and rodents that may transmit disease;
- always washing your hands after gardening.

4.2 Mosquito Breeding

A major concern with using greywater is the potential health risks associated with ponding of greywater from unsatisfactory disposal practices and inadequately maintained greywater facilities. Surface ponds of greywater and poorly maintained greywater treatment plants provide ideal breeding habitats for mosquitoes.

The fresh water breeding mosquito, *Culex annulirostris*, transmits Ross River and Murray Valley Encephalitis viruses. This mosquito is quite capable of breeding in temporary and semi-permanent ponds that develop through poor wastewater disposal practices. The mosquito, *Aedes aegypti,* which transmits dengue fever, will also breed in any treatment plant, holding tank or receptacle where water is allowed to stagnate for a few days.

The potential for mosquito breeding can be minimised by:

- preventing surface ponding and confining greywater within the land application area;
- ensuring tanks making up the treatment plant, and holding tanks are properly sealed against the ingress of mosquitoes.

4.3 Storage of Greywater

All forms of wastewater when stored will turn septic unless the wastewater is treated to a high standard. Similarly, when greywater is stored it will also turn septic giving rise to offensive odours and provide conditions for microorganisms to multiply. Thermotolerant coliforms have been found to multiply by 10 to 100 times during the first 48 hours of greywater storage before gradually declining. Significant levels of pathogens have been found in stored greywater after eight days.

Should the stored septic greywater be surface irrigated it will give rise to extremely offensive odours, provide conditions conducive to disease transmission and attract insect and rodent vectors. Greywater must not be stored, other than temporarily, unless adequately treated.

4.4 Effects of Excessive Watering Using Greywater

Over application of untreated greywater to a land application area may result in the development of unsightly areas of grey/green slime. This slime is caused by the presence of soaps, shampoos, detergents and grease in the greywater. Excessive watering with greywater on a small area will cause surface runoff or seepage to stormwater drainage, which ultimately finds its way to a natural watercourse.

If greywater is continuously applied to soil, chemical contaminants may cause damage to the soil structure and clogging of the soil's pore structure. Healthy plant growth is not promoted under these conditions.

The effects of excessive watering using greywater can be minimised by;

- having multiple irrigation areas to allow rotation of irrigation
- having adequate irrigation area for the quantity of greywater available and the site and soil conditions.

4.5 Land Requirements for Treated Greywater Irrigation

For the sustainable use of treated greywater there should be adequate irrigation area so that there is no on-site water logging, no run-off of potentially contaminated water, no unwanted ecological effects on the surrounding land and finally no increased health risks resulting from land application. The typical pathway for water recycling is to apply treated greywater to land to irrigate plants. Sustainable recycling of treated greywater occurs when it is applied to meet the plant requirements and there is negligible discharge to the environment.

The land area required for irrigation is based on the capability of the soil to receive the treated greywater and the estimated daily greywater flow. Appendices 4.1C, 4.1D and 4.2A of AS/NZS 1547:2000 may assist in determining the soil capability and sizing of the irrigation area. It may also be appropriate to engage a site and soil evaluator to prepare the site assessment and application to the local government for approval to install the greywater facility.

5 DESIGNING A GREYWATER FACILITY

5.1 Performance Objectives

Performance objectives for on-site domestic wastewater management have been developed and can be found in AS/NZS 1547:2000. The performance objectives help to make sure that on-site sewage management for single households is appropriate and will not affect public health or the environment.

5.2 Greywater Quality for Recycling or Disposal

All greywater that does **not** meet secondary effluent standard given in Table 4, must be discharged to a subsurface land application system e.g. absorption trench, evapotranspiration area, and subsurface irrigation. The greywater normally does not require disinfection prior to discharge to a subsurface land application system.

Table 4
Effluent quality based on level of treatment

Parameter	Primary Effluent g/m^3 *	Secondary Effluent g/m^3	Advanced Secondary Effluent g/m^3
Biochemical oxygen demand	120-240	20	10
Total suspended solids	65-180	30	10
Thermotolerant organisms (org/100ml)	Not applicable	200	10

* note 1 g/m^3 = 1 mg/L

Source: Department of Natural Resources & Mines, (2002) "Guidelines for Effluent Quality".

Greywater that has been treated so that the effluent quality after treatment meets secondary standard or better may be discharged to a land application area by surface irrigation. The treated greywater must be disinfected prior to surface irrigation.

Surface irrigation is considered to be:

a) spray irrigation where sprinklers disperse the effluent over the land application area, or

b) surface drip irrigation where the effluent is distributed from a perforated small diameter pipe installed on the natural surface.

Where a layer of mulch e.g. pine bark covers the distribution system, the effluent is to be secondary standard and disinfected.

There may be subsurface discharge situations, e.g. shallow groundwater table where the local government may consider disinfection as being appropriate to minimize the potential for pathogenic organisms entering the groundwater. In such cases, the approval to install the on-site sewerage facility may include an "on-site facility condition"[5] that requires the effluent to be disinfected. The condition must be complied with.

[5] Standard Sewerage Law 1998, Section 72 Approval needed.

5.3 Site and Soil Evaluation

Before commencing the design of the greywater recycling facility a site and soil evaluation should be undertaken. The procedures for carrying out a site and soil evaluation are given in the "On-site Sewerage Code" and AS/NZS 1547:2000. The site and soil evaluation should provide information on the following:

- Information to determine the most appropriate method of recycling treated greywater
- Depth and permeability of the soil;
- The risk of prejudicing adjoining property, underground water supplies and or swimming pools and wading pools and the like by spray drift, seepage or runoff from the site;
- Any seasonal changes in groundwater level and adsorptive capacity of the site;
- The general climate and its effect on the evaporation or transpiration from the site; for example seasonal distribution of rainfall, hours of sunshine, prevalence of wind;
- The effects of seepage and surface water from surrounding areas at higher levels than the proposed land application area.
- The type of vegetation present on the site.

Because greywater contains many impurities, including nutrients such as nitrogen and phosphorus, which may harm the environment and the soil in particular, great care must be exercised when designing land application areas to ensure that they are sustainable. There are some chemicals, which are not capable of being treated or degraded in the soil. Therefore the soil ecosystem must be capable of adsorbing, absorbing, assimilating or treating the chemical impurities and nutrients without medium and long-term degradation of the soil or the environment. Domestic greywater treatment systems are designed primarily to treat organic matter and are not normally designed to remove chemical salts such as sodium, nitrates and phosphates that may be found in greywater.

5.4 Irrigation System

Unless filtered effectively greywater will contain non-soluble particles, such as, hair, lint and dirt that may cause blockages in the irrigation pipework in the land application area. Coarse screening is essential to prevent blockages in pumps and in the irrigation pipework and orifices. However, the filters will need frequent maintenance to ensure the blockages are minimised.

Modern drip emitters are designed to minimise clogging by roots. For example, one proprietary brand emitter is treated with a herbicide to protect them from root intrusion. The emitters are designed with a turbulent flow path to minimise clogging from suspended solids. As greywater contains both microorganisms and nutrients for their growth, a biofilm of microorganisms may develop on the inside of pipes and drippers used to distribute greywater. Periodic chlorination of the irrigation pipework may be necessary to avoid biofilm growth. The distribution system should also be equipped with flush valves to permit back flushing.

6 DOMESTIC GREYWATER SYSTEMS

Greywater recycling options range from primary treatment systems to the more expensive secondary treatment systems. The choice of system is dependent on a number of factors including:

- the owners willingness to operate and maintain the facility,
- the size of the allotment,
- source of greywater to be recycled.

Options for recycling greywater are listed below.

6.1 Primary Diversion Systems

Primary diversion methods use coarse screen filters or sedimentation to remove oils/greases and solids prior to discharge to the land application areas by sub-surface irrigation methods. These systems are likely to be considered the most economically attractive for greywater use because maintenance can usually be carried out by the homeowner and generally do not rely heavily on electricity or chemicals to operate. Examples are given in the following sections.

6.1.1 Gravity Diversion Systems

A gravity diversion device incorporates a hand activated valve, switch or tap which is fitted to the outlet of the waste pipe of the plumbing fixture such as laundry tub. The plumbing diversion device can be switched by the householder to divert greywater from the laundry tub by gravity directly to the diversion line and the dedicated land application area. The greywater must not be stored. Gravity diversion devices must not be installed below the "S" bend on any plumbing fitting. The greywater must be discharged to a sub-surface irrigation system.

These systems do not require either model or type specification approval from the Department of Natural Resources & Mines.

6.1.2 Pump Diversion Systems

The pumped diversion system directly recycles untreated domestic greywater (sources from the bathroom and/or laundry fixtures) for subsurface lawn and ornamental garden watering. These systems do not allow storage or treatment, apart from the use of in-line filters to remove lint, hair and coarse particles. The system incorporates a surge tank to temporarily hold large drain flows from washing machines and bathtubs before distribution by a pump to a subsurface land application area. The surge tank does not operate as a storage tank. The greywater may be screened as it enters the surge tank.

The pumped greywater diversion system should have the following features:

- The capacity of the surge tank should be based on household fixture ratings of AS/NZS 3500 National Plumbing and Drainage. The operating volume should be adequate to hold the emptying of the washing machine and bathtub simultaneously.

- The surge tank and associated pipework should be vented. Vents should be constructed as per AS/NZS 3500 National Plumbing and Drainage.

- The materials used and the construction of the surge tank should be in accordance with the relevant requirements of AS/NZS 1546.1 "On-site domestic wastewater treatment units Part 1; Septic Tanks"

- Access openings to the surge tank should be fitted with a locking gasket cover, or approved equivalent, to allow inspection and cleaning, and to prevent entry of mosquitoes, flies and vermin. Access opening covers must be child proof.

- For subsurface irrigation systems a 140 mesh (115 microns) filter with a capacity of 100 litres per minute should be installed between the pump and the irrigation area. The filter should be installed so that is readily accessible for cleaning purposes.

- An overflow drain may be provided at top water level of the surge tank connecting to a soil absorption trench or the septic tank. The overflow should have a diameter not less than the inlet pipe diameter. The capacity of the absorption trench should be based on the household fixture ratings of AS/NZS 3500 National Plumbing and Drainage. The purpose of the overflow drain is to minimise the occurrences of overflows from the surge tank due to pump failure, filter blockage, or power failure.

- The surge tank may be fitted with a high water level warning device to warn of pump failure or system blockage. For systems fitted with an overflow drain the alarm should trigger prior to overflow to the soil absorption trench or septic tank.

- The surge tank may be fitted with an electrically driven pump or equivalent approved by the local government. The pump should be fitted with an automatic on/off function e.g. float switch or electrodes. The pump should automatically operate when flow enters the surge tank.

- The subsurface irrigation area should be sized in accordance with AS/NZS 1547:2000 "On-site domestic-wastewater management.".

- The subsurface irrigation system should be designed and installed in accordance with AS/NZS 1547:2000.

- Valves, switches, timers and other controllers may be used, as appropriate to rotate the distribution of greywater between the irrigation zones and to schedule irrigation.

Figure 2 shows a conceptual layout of the surge tank and the subsurface irrigation area.

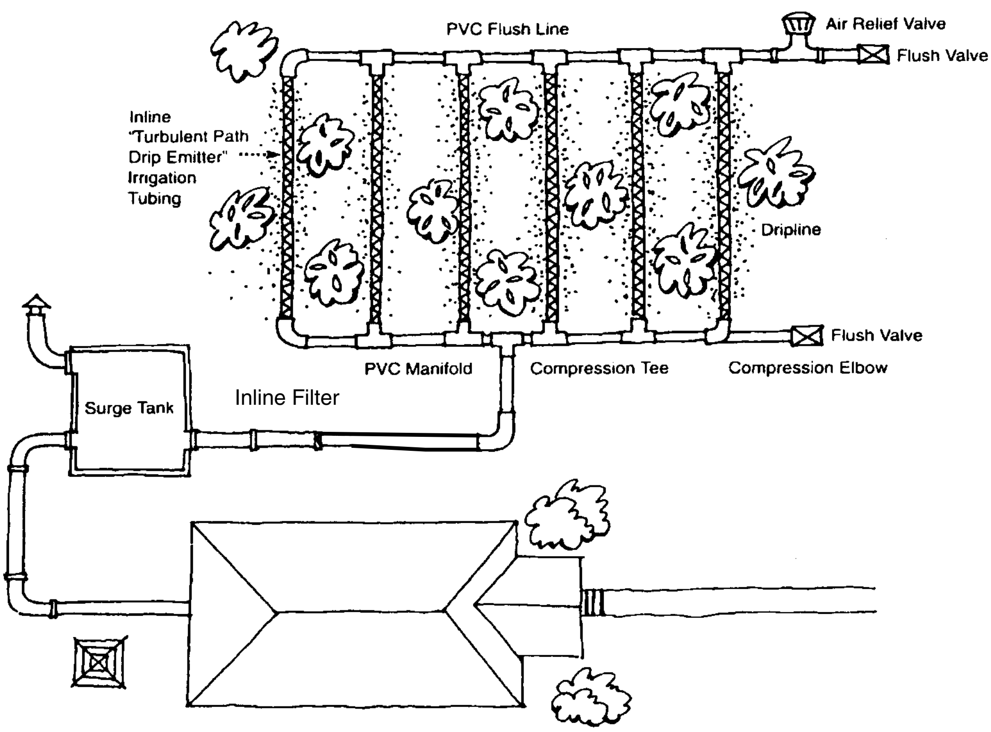


Figure 2 – Conceptual Layout for Surge Tank and Subsurface Irrigation Area *(Adapted from Jeppersen and Solly, 1994)*

Primary treatment systems such as described above would not require model or type specification approval from the Department of Natural Resources & Mines.

6.2 Secondary Treatment Systems

Secondary treatment systems further treat the greywater to remove more of the oils/greases solids and organic materials. This allows secondary treated greywater to be irrigated via micro-drip or surface irrigation methods (where disinfected). These systems are generally more expensive due to the initial establishment costs associated with the further treatment needs and ongoing maintenance costs. However, the treatment level enables a much more conventional surface irrigation system and less health risk with human contact.

Secondary treatment systems will require either model or type specification approval from the Department of Natural Resources & Mines in accordance with the On-site Sewerage Code.

6.3 Other Treatment Systems

Other examples of greywater recycling systems that do not incorporate typical primary or secondary treatment systems are considered in a number of worldwide publications. Some are natural systems such as artificial wetlands or systems that physically capture/filter out solids from specific greywater streams. Some of these systems require ongoing householder maintenance to regularly clean filters. It is likely that with the introduction of these guidelines, interest in other treatment systems and products will occur.

6.4 Disinfection

Disinfection is the process of inactivating pathogenic microorganisms in wastewater. The disinfection process efficiency is measured by the analysis of thermotolerant coliforms, as an indicator of microorganism contamination and is discussed in Section 2.3.1. Some pathogenic microorganisms (eg *Giardia, Cryptosporidium*) are resistant to the usual disinfectant concentrations and therefore caution is still to be exercised in managing greywater dispersal.

High suspended solids and the presence of certain ions and organic matter can reduce the effectiveness of disinfecting agents. Some combinations of surfactants can neutralise a disinfectant (Christova-Boal, et.al., 1995). When disinfection is necessary the greywater should be treated to lower the biochemical oxygen demand and suspended solids to produce a clear effluent.

Some environmental conditions such as sunlight and drying exhibit a disinfection effect. This effect however is minor and is negated by shade and irrigation at night.

In the absence of disinfection the "barrier approach" is used to reduce the risk human exposure to the greywater. A barrier e.g. 100 mm of soil is placed over the greywater distribution system so as to prevent human exposure to the greywater that has not been disinfected.

7 USING, MONITORING AND MAINTAINING THE FACILITY

7.1 Protect Health

If a member of the house is ill or is carrying a subclinical infection, greywater may carry infectious bacteria or viruses. However, in order for the greywater to make another person ill it would be necessary for that person to drink or otherwise consume the contaminated greywater, inhale aerosols, touch or consume items which have come in contact with contaminated greywater. It is important to wash vegetables that may have come in contact with treated greywater before they are eaten or ensure that vegetables are not planted in an area that is being irrigated with treated greywater.

The objectives of the standards are to avoid human contact with greywater. Greywater systems designed, installed and maintained in accordance with the "On-site Sewerage Code" and this guideline present minimal risk to public health.

When greywater is being used follow these rules:

- Don't drink or play in greywater.
- Don't allow anything that may be eaten to come in contact with greywater.
- Don't allow greywater to pond on the surface or run off the property.
- Don't wash domestic pets in greywater or allow these pets to drink the greywater.
- Do wash your hands after contacting greywater or otherwise dealing with greywater eg gardening, cleaning filters.

7.2 Selection of Household Detergents, Soaps, Cleaners

The chemical and biological quality of greywater varies greatly, based on numerous factors, including the original quality of the water coming into the dwelling, the personal habits of family members, which plumbing fixtures are connected to the system and the soaps used. Since the type of detergent selected is one factor that the owner can control, the use of garden friendly soaps can contribute to a better quality greywater.

Most hand and dishwashing detergents and shampoos will not damage plants at low residential concentrations. Laundry detergents, on the other hand, need to be selected carefully. Sodium and boron are chemicals that can have a negative effect on landscapes. Powdered detergents and soaps include "filler" ingredients (not essential to clothes cleaning), which are usually some compound of sodium. Liquid soaps contain few fillers, thus less sodium.

7.3 Keeping the Soil Healthy

Laundry detergent powders contain only about 15-20% of a detergent, with the rest being various compounds of sodium. Because of the presence of these sodium compounds in laundry detergent, greywater can be very alkaline (pH 8.0 – 9.2) and their accumulation over a period could raise the pH of some soils to a level that is high enough to damage plants (Handreck, 2001). Slightly alkaline soils will support many garden plants. Even most acid-soil loving plants will be happy with slightly alkaline soils that are generously amended with organic matter. If a simple pH test indicates that the pH reading is over 8.0 the pH should be reduced.

This can be accomplished by adding agricultural sulphur or an acidifying fertiliser such as ammonium sulphate.

The high sodium content can seriously damage the structure of clay soils. What happens is that sodium gradually replaces calcium and magnesium on the surfaces of particles in the soil, so creating a "sodic" soil. As long as the irrigation water i.e. the greywater remains saline, the aggregates in the soil may remain intact, but if salinity falls (as during rain) the aggregates fall apart. Particles "float off" or disperse into the soil water and clog the soil pores, so forming a compacted layer at the surface (Handreck, 2001).

To correct these problems and keep soil healthy, once again, till in organic matter or add gypsum. Do not let the soil dry out, as this will cause the concentration of salts in the remaining water to become very high. This effect is greatest in sandy soils. Leach excess salts from the soil. Leaching is easiest when soil structure is good. Add 10-20% more water that is needed to fill the soil reservoir each time the soil is watered.

The book "Grow What Where" by the Australian Plant Study Group contains an extensive listing of Australian native plants of known high tolerance to saline soils.

7.4 Healthy Plants

The application of too much water, of any kind, too frequently will result in saturated soils and an invitation to plant disease. Maintaining an even and constant, but low, moisture level through the soil will best promote plant growth.

A very small percentage of plants may be damaged by greywater. A local nursery should be consulted on the plants that may be damaged by greywater. Too much sodium or chlorine could result in leaf burn, chlorosis (yellow leaves) and twig die back. Boron can be toxic to plants at levels only slightly greater than is required for good plant growth. Symptoms of boron toxicity include leaf tip and margin burn, leaf cupping, chlorosis, branch die back, premature leaf drop and reduced growth.

7.5 Disposal of Screenings and Filter Waste

Coarse screen waste and in-line filter waste material must be buried with a minimum cover of 150 mm soil over the material. The waste material is to be buried in soil where the cultivation of root vegetables is not intended.

The waste material is to be buried within the property boundary.

7.6 Desludging

Surge tanks and other wastewater treatment units may require desludging at regular intervals eg. Every five years or when the sludge occupies one third of the volume of the surge tank. The pumped material is to be disposed of in accordance with the requirements of the local government.

7.7 Monitoring the Facility

It is important to check the facility on a regular basis, every week or so, to see that greywater is not surfacing or ponding, that the plants and soils are healthy and the equipment is working properly. An operation and maintenance manual should be supplied with the greywater system at installation. The system components should be maintained and serviced if necessary in accordance with instructions in the manual.

The main concern with drip irrigation systems is the possible clogging of the emitters, preventing flow of water to the plants. With properly selected and maintained filtration and occasional flushing of the subsurface drip irrigation system, most problems with emitter clogging can be avoided.

8 FURTHER READING

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APPENDIX 1

Calculating Daily Greywater Flow

To estimate the quantity of greywater available for use from a house with 3 bedrooms and four occupants.

1. Assume that only bathroom greywater is to be used for landscape watering.
   Daily greywater flow from bathroom = 60 litres/person/day
   Total greywater volume from bathroom = 4 persons x 60 litres/person/day
   = 240 litres/day
   The above assumes no water saving devices in the bathroom.

2. Assume that bathroom and laundry greywater is to be used
   Daily greywater flow from bathroom = 60 litres/person/day
   Daily greywater flow from laundry = 35 litres/person/day
   Total for bathroom and laundry = 95 litres/person/day
   Daily greywater volume = 4 persons/day x95 litres/person/day
   = 380 litres/day
   The above assumes a top loading washing machine and no water saving devices.
   Flow from laundry will vary depending on days washing is done.