Technical Guide for GREYWATER Recycling System

Sep 2014

Design, installation, testing, operation and maintenance of greywater recycling systems for collection and treatment of greywater and supply of the treated greywater for the below non-potable water use in buildings:

i. flushing of water closets and urinals,
ii. general washing,
iii. irrigation, and/or
iv. as cooling tower make up water.

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Water for All : Conserve, Value, Enjoy

GREYWATER

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Introduction

Singapore, an island with limited natural water resources has turned its vulnerability to strength. Today, the nation has built a robust, diversified and sustainable water supply from four different sources known as the Four National Taps (water from local catchment areas, imported water, high-grade reclaimed water known as NEWater and desalinated water). The country has also managed the water demand efficiently over the years. By adopting a sustainable water management strategy, Singapore has ensured a stable, sustainable water supply capable of catering to the country's continued growth.

Greywater recycling is yet another step towards ensuring proper and effective use of water. There exists opportunity for appropriately treated greywater to be recycled for different non-potable end uses, such as flushing of water closets and urinals, and cooling tower make up water. Using treated greywater will reduce the demand on potable water/NEWater supplies. Recycling of greywater is therefore supported and encouraged by PUB from water conservation perspective. However, this has to be accomplished without compromising public health and causing unacceptable environmental impact.

The objective of this technical guide is to provide the guidance needed for the safe use of treated greywater, while minimizing the associated human health and environmental risks.

It aims to guide the building owners & Qualified Persons in the type, design, installation, testing, operation and maintenance of greywater recycling system intended to supply non-potable water for flushing of water closets and urinals, general washing, irrigation and for cooling tower make up water. This guide stipulates only the minimum and mandatory requirements to be complied with to ensure reliable systems are designed, installed and maintained to protect the public.

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Scope

This technical guide provides requirements on the design, installation, testing, operation and maintenance of greywater recycling systems for collection and treatment of greywater and supply of the treated greywater for flushing of water closets and urinals, general washing and irrigation and/or as cooling tower make up water in buildings.

It does not cover direct reuse greywater systems (no treatment).

NOTE:

(a) PUB does not allow the use of greywater recycling system for individual household uses or retail uses as it is difficult to manage the associated potential health risks of poorly maintained individual household systems.

(b) To safeguard public health, treated greywater shall not be used for high pressure jet washing or irrigation sprinklers. The use of treated greywater for general washing at markets and food establishments is also not allowed.

Terminology

Blackwater	Domestic used water contaminated with faecal matter and urine.
Disinfection	means a process that removes, destructs or renders harmless to human health the pathogenic microorganisms and parasites that would otherwise be present in water. The process of disinfection will thus eliminate many or all pathogens. However, it may not sterilise the water or eliminate resistant bacteria spores.
Greywater	means untreated used water which has not come into contact with toilet waste. It includes used water from showers, bathtubs, bathroom/toilet wash basins and water from clothes-washing and laundry tubs. It shall NOT include used water from urinals, toilet bowls (water closets), kitchen sinks or dishwashers.
Greywater Recycling	refers to use of treated greywater after the greywater has gone through treatment such as membrane filtration and disinfection to render the treated greywater safe for non-potable use complying with the required water quality suitable for the specific use as specified in Part 4, Table 1 of this Guide. Treated greywater may be used for flushing of water closets and urinals, general washing and irrigation and/or as cooling tower make up water. However, treated greywater shall not be used for high pressure jet washing or irrigation sprinklers, etc as there may be public health concerns.

Greywater recycling system	means a greywater collection, treatment and treated greywater distribution system, excluding standalone greywater recycle or reuse systems or units, such as those installed by individual households, which are not covered under the scope of this Guide.
Non-potable water	water other than potable water.
Nutrients	mean chemical elements essential for sustained plant or animal growth. The major nutrients essential for plant growth are nitrogen, phosphorus and potassium.
Ozonation	means use of ozone to disinfect treated greywater and for removal of organics.
Pathogens	mean micro-organisms that are capable of causing disease in human and animals e.g. viruses, bacteria, helminths and protozoa.
Potable water	water supplied that is fit for human consumption.
Toilet Flushing	refers to flushing of water closets and urinals.
Treated Greywater	means greywater which, as result of treatment, is rendered safe for non-potable use complying with the required water quality suitable for the specific use as specified in Part 4, Table 1 of this Guide.
Treatment	means any physical, chemical and/or biological method used to purify, clean or disinfect greywater, including but not limited to aeration, chemical disinfection (e.g. chlorination, ozonation), biological treatment, sedimentation, coagulation, UV radiation, ozonation and ultrafiltration/microfiltration.
Ultraviolet (UV) Treatment	means using UV light to disinfect treated greywater at required dosage.
Used water	means water that has been contaminated by some activity, containing dissolved and suspended matter. Include greywater and sewage in general.

PART 1 Greywater

1.1 Definition

1.1.1 This Technical Guide considers greywater as untreated used water which has not come into contact with toilet waste. It is collected from showers, wash basins, bathtubs, bathroom/toilet wash basins and water from clothes-washing and laundry tubs. It shall not include used water from urinals, toilet bowls (water closets), kitchen sinks or dishwashers.

1.1.2 It excludes the used water discharged from kitchen sinks and dishwashers due to the presence of grease and oil, high organic content leading to oxygen depletion and increased microbial activity of the greywater that could lead to increased microbial risks due to Singapore's tropical climate.

NOTE: In premises where any wash basins and sinks are specifically designated for washing of materials contaminated with faecal matters, the used water from such sources should not be mixed with the greywater intended for recycling. In addition, in the healthcare facilities, where patients having infectious diseases are treated, the used water from wash basins and sinks should not be recycled. In all other premises where the used water discharged from the wash basin might have a quality deviating from the norm, approval from the authority to use it as a greywater source has to be sought.

1.1.3 Blackwater is the used water discharged from toilet bowls and urinals and it contains human waste (faeces and urine). All blackwater should be directly discharged into the sewerage system.

1.1.4 Recycling treated greywater provides a number of benefits including reducing:

- potable water/NEWater demand
- volume of used water discharged into the sewerage system
- water bills

1.2 Sources and Quantities

1.2.1 The sources and quantities of greywater vary greatly according to the nature and business of commercial, industrial and other non-residential buildings and the usage behaviour of households for residential buildings. The amount of greywater generated from any building is influenced by factors such as the number of occupants, the age distribution of the occupants, their lifestyle characteristics and water usage patterns.

1.2.2 **Bathroom Greywater** (bath, wash basin, and shower) contributes about 40% of the total usable greywater volume. The quality of bathroom greywater depends on the behaviour of the people using the appliances and it can be contaminated with hair, soaps, shampoos, hair dyes, toothpaste, lint, nutrients, body fats, oils and cleaning products. It also contains some faecal matter (and the associated pathogens) from body washing.

1.2.3 **Laundry Greywater** contributes about 20% of the total usable greywater volume. Used water from the laundry varies in quality from wash water to rinse water to second rinse water. Laundry greywater can contain faecal matter with the associated pathogens, lint, oils, greases, chemicals, soaps, nutrients and other compounds derived from soiled clothes or cleaning products.

1.2.4 It is estimated that a commercial building with 1000 staff generates about 20,000 to 25,000 litres of greywater per day.

1.3 Characteristics

1.3.1 The quality of greywater can be highly variable due to factors such as the number of staff in commercial/office building and for household occupants, their age, lifestyle, health, water source and products used (such as soaps, shampoos, cleaning products) and other site specific characteristics.

1.3.2 Greywater is contaminated in three ways due to the addition of waste substances:

- the water is contaminated by micro-organisms, 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 micro-organism and plant growth; and

- the water may be physically polluted by particles of dirt, food, lint, sand, etc.

The typical physical, chemical and microbiological quality of greywater is provided at **Annex 1** for reference.

1.4 Environmental Risks

1.4.1 The major risk of human contact with greywater is infection and illness resulting from viruses, bacteria and other pathogens. Chemicals in greywater can also cause adverse health effects after prolonged periods of human exposure.

1.4.2 To minimise negative impacts on the environment from greywater recycling, the following requirements shall apply:

(a) Greywater shall be adequately treated and disinfected to meet the required water quality before it is re-used for toilet flushing, general washing, irrigation and/or as cooling tower make up water.

(b) Waste chemicals such as paints, automotive oils and greases, pesticides and pharmaceuticals waste, etc and any other trade waste or industrial liquid waste shall not be discharged into the greywater recycling system.

(c) Greywater shall not be permitted to run off onto neighbouring properties or driveways, car parks or any hard surfaces where it can run into the street and into stormwater drains and eventually into surface waters. Also, the greywater or the used greywater shall not be discharged into open drains or rivers leading to the sea or reservoirs. They shall be discharged into public sewer or recycled for other uses.

1.5 Public Health Considerations

1.5.1 Greywater is capable of transmitting disease through contact via contaminated hands, inhalation of greywater spray and contact with broken skin or indirect contact via contaminated items such as toys, garden equipments, grass or soil.

1.5.2 Protection of public health is of utmost importance. The more 'barriers' there are between the greywater and the public, the lower the risk of exposure to pathogens and contaminants. For example combining a tertiary treatment process with reliable disinfection, well maintained pipes, application controls and restrictions will reduce risks to public health by improving treated greywater quality and lowering exposure to greywater.

1.5.3 In order to reduce the risk to public health and to ensure that the greywater recycling system does not cause any public health nuisance, the following requirements shall apply:

(a) The treated greywater shall be used strictly for non-potable purposes and shall be limited to toilet flushing, general washing, irrigation and/or cooling tower make up.

(b) The treated greywater shall meet the treated greywater quality requirements as mentioned in Part 4, Table 1 of this Guide. The minimum sampling and monitoring regime for the treated greywater quality shall be in accordance with Table 2, Part 4 of this Guide.

(c) There shall be no inter-connection or cross-connection between a pipe or fitting for conveying, storing or containing water supplied by PUB (i.e. potable water or NEWater) and a pipe or fitting for conveying, storing or containing non-potable water including greywater. The provision of mechanical backflow prevention devices is not a permissible substitute for complete absence of connection. No non-potable water pipe including pipes conveying or containing greywater shall be laid above any PUB water supply pipe. Where unavoidable, the PUB water supply pipe shall be adequately protected against possible contamination.

(d) Equipment, devices, pipes and fittings for the conveyance, treatment, storage and use of greywater shall be labelled in accordance with Clause 2.11 of this Guide.

(e) The treated greywater shall not contain harmful agents that cause infectious disease or endanger public health through human exposure by direct contact, ingestion, or inhalation.

(f) The greywater tanks are to be mosquito-proof in accordance with Clause 2.5.12 of this Guide.

(g) The quality of the treated greywater shall not have any adverse impact on the environment and public health and the equipment, devices, pipes, fittings and materials with which the greywater comes into contact with.

(h) The greywater recycling system shall be operated and maintained in such a way that it does not cause any public health nuisance such as excessive noise, odour problems, mosquito breeding, etc.

(i) If the treated greywater is to be used in cooling towers as make up water, a separate approval from the National Environment Agency (NEA) shall be obtained under the provisions of the Environmental Public Health (Cooling Towers and Water Fountains) Regulations.

1.6 Allowable Uses of Treated Greywater

1.6.1 Treated greywater may be used for toilet flushing, general washing, irrigation and/or as cooling tower make up water. However, the use of treated greywater for general washing at markets and food establishments is not allowed.

1.6.2 Treated greywater shall not be used for retail uses including high pressure jet washing or irrigation sprinklers as there may be public health concerns.

PART 2 Types, Design and Installation

2.1 System Type and Treatment Capacity

2.1.1 It is essential that greywater systems are designed in a way that ensures the treated water is fit for purpose and present no undue risk to health for supply of non-potable water for toilet flushing and/or as cooling tower make up water at building or district level.

Treatment Process:

2.1.2 Typically, a greywater treatment system should be designed with a biological & filtration (microfiltration, ultrafiltration or membrane filtration) steps and disinfection processes capable of producing a stable final treated greywater quality that comply with the required quality standards as specified in Clause 4.1.2 Table 1 of this Guide.

2.1.3 Chlorine dosing facility shall be provided at the treated greywater storage and supply tank for final disinfection ensuring the supplied water is sterile and residue chlorine is maintained throughout the storage period.

Coloring dye injection unit:

2.1.4 Colouring dye dispenser device shall be provided to inject blue dye to the treated greywater before being supplied to the WC flushing cisterns or urinals so that the users are aware that the water is not potable. The blue colour also reduces the risk of cross-connections and the possibility of greywater being use for inappropriate purposes. A safe and environmental friendly dye (food-grade dye) shall be used.

2.1.5 The following factors should be identified in order to determine the type and treatment capacity of the greywater recycling system:

(a) demand and yield, based on:
i) the number and type of intended applications, both present and future;
ii) the volume and usage patterns of these applications;
iii) discharge figures for showers, baths, wash and hand basins and washing machines connected for reuse;

(b) water quality requirements for the intended uses (see Part 4, Table 1);

(c) peak treatment rate & capacity of the plant.

2.2 Sizing

2.2.1 Depending on the type of greywater system, the optimum storage capacity for treated greywater should be determined by the following factors (also refer to clause 2.5):
(a) the peak treatment rate & capacity of the plant;
(b) the demand, usage or behaviour patterns.

2.2.2 The storage of treated greywater shall be minimized to that needed for immediate use. As there is generally a ready supply of untreated greywater, storage equal to a 1 day's use is normally considered sufficient.

2.3 Collection

2.3.1 Greywater shall be collected in separate sanitary pipework and allowed to flow from collection appliances (e.g. shower, bathtubs, and bathroom wash basins) to the greywater recycling system by gravity. Where gravity flow is not practicable, e.g. in single-storey dwellings, pumps need to be considered.

2.3.2 Greywater collection pipework shall be designed, sized and installed in accordance with the Code of Practice on Sewerage and Sanitary Works. Pipes and fittings of equal material, quality and construction for sanitary plumbing system shall be used.

2.3.3 No blackwater, hazardous chemicals or contaminated water shall enter the greywater recycling system.

2.3.4 Bypass pipe and appurtenances (valves, etc) shall be fitted around the greywater recycling system to allow the collected greywater to flow directly to the sanitary/sewerage system during periods of maintenance, blockage or system isolation.

2.3.5 All greywater collection pipes and fittings shall be prominently marked and identified as conveying greywater.

2.4 Treatment and Disinfection

2.4.1 Greywater treatment shall achieve the following objectives:
(a) provide a level of treatment consistent with the proposed non potable use.
(b) treat greywater to a level to protect human health from the effects of toxicants and microorganisms.

2.4.2 Below are the minimum requirements to achieve the above objectives:
(a) the level of treatment for greywater satisfies the water quality limits specified in the Table 1 at Clause 4.1.
(b) treatment and use of treated greywater is managed to satisfy the criteria specified in this Guide.
(c) the greywater treatment process has the capacity to effectively treat the maximum daily flows.
(d) the disinfection process used for treating greywater is able to reduce or deal with infectious components to the levels for the intended use or degree of public access that satisfies the requirements detailed in this Guide.
(e) discharges of greywater into the public sewerage system do not contain hazardous substances exceeding the limits specified in the Sewerage and Drainage (Trade Effluent) Regulations.
(f) the greywater treatment process has the facilities to effectively manage the bio-solids generated in an environmentally acceptable way.
(g) The greywater treatment process uses the best available technology considering factors such as required level of treatment, system technical capabilities, stand-by systems and ability to handle extreme events.

2.4.3 The types of proven treatment processes and disinfection processes to meet the treated greywater quality requirements specified in this code are provided in **Annex 2** and **Annex 3** of this Guide.

2.4.4 The treatment technologies to be applied and the appropriate treatment process for greywater recycling system for each individual project shall be determined based on the greywater availability and quality, consumption demands and the treated greywater quality requirements for the intended applications, etc.

2.4.5 Backwash water and overflow from the treatment system shall be discharged through the building's sanitary drainage system (i.e. floor trap or inspection chamber) into the public sewerage system.

2.5 Storage

2.5.1 The storage of raw/untreated greywater should be avoided, wherever possible. Raw/untreated greywater shall only be stored temporarily in a tank, **for less than 24 hours.**

2.5.2 The storage of treated greywater shall be incorporated as part of the greywater recycling system. The selection of storage shall take into account:
(a) the maximum flow rate the treatment equipment delivers;
(b) the necessary storage temperature;
(c) the maximum storage period; and
(d) any other conditions stated by the manufacturer of the treatment equipment;

2.5.3 The storage volume depends on the user habits (daily course of greywater supply and consumption) as well as the process requirements (hydraulic retention time, i.e. rapid or time-consuming treatment). The buffer and storage capacities in total shall under no circumstance be larger than the greywater demand for 24 hours. It is essential that the treatment system operates regularly as stagnant water may lead to microbiological growth. Generally, storage equal to a 1 day's use is normally considered sufficient.

2.5.4 The stored treated greywater shall be dosed with chlorine to maintain the required chlorine residual (refer to Part 4 Table 1) at all time. Stored treated greywater that does not conform to the required water quality shall be drain-off into the sanitary/sewerage system.

2.5.5 All storage tanks, cisterns and access fittings shall be clearly marked and identified as containing greywater. Greywater tanks and pumps shall not be sited in the same room/enclosure as potable/NEWater tanks and pumps.

2.5.6 All storage tanks shall be constructed to form a watertight structure. The materials for the tank and other components shall not encourage microbial growth, suitable materials include concrete, glass reinforced plastic (GRP), polyethylene or polypropylene and steel coated with non-corrodible materials.

2.5.7 All storage tanks and cisterns shall avoid water stagnation by ensuring that pipework connections allow the through-flow of water.

2.5.8 All storage tanks shall be fitted with a warning mechanism that alerts the user to the failure of the inlet control valves (e.g. float valves in the storage tanks) for raw greywater and back-up water supplies to close correctly. This warning may involve a warning pipe that can be readily seen or an electronic device, such as an alarm. The warning mechanism shall activate before the water level overflows.

2.5.9 All storage tanks and cisterns shall have an overflow which is connected to the sanitary/sewerage system, screened ventilation and fitted lids to prevent contamination of the treated water.

2.5.10 All storage tanks and cisterns should be sited such that the stored water does not attain temperatures that could encourage unwanted microbial growth. Where tanks are positioned above habitable or vulnerable areas, the risk of water leakage should be considered, e.g. bunding, additional drainage, sump pump.

2.5.11 All storage tanks shall be covered and protected against direct sunlight (e.g. in the cellar without windows) or manufactured from an opaque material in order to avoid the possible growth of algae.

2.5.12 All storage tanks shall be cleaned at least once annually.

2.5.13 All storage tanks shall be mosquito-proof in accordance with the "Guidelines on Mosquito prevention in domestic rainwater collection system for non-potable uses". A copy of the Guideline is available at:
http://www.nea.gov.sg/cms/ehd/Guidelines_on_RainWaterCollectionSystem.pdf

Emergency Storage and Disposal

2.5.14 Where problems may arise with the greywater recycling system, emergency facilities shall be provided to store and/or safely dispose of treated greywater that does not meet the treated greywater quality requirements into the sewer.

2.6 Back-up water supply

2.6.1 Back-up PUB water (potable water or NEWater) supply shall be introduced into the treated greywater supply tank which is usually located at high level to ensure continuous water supply for flushing the water closets and urinals in the event of power failure, equipment failure or maintenance shutdowns. Backflow prevention shall be fitted in accordance with Clause 2.7.

2.6.2 The back-up water supply shall be sized to allow it to meet the full demand requirements. The impact that a sudden demand from the back-up mechanism might create in operation on the water supply, particularly in large communal systems, should be considered and it is important that the water supply infrastructure is capable of meeting this increase.

2.6.3 The back-up water supply shall be fitted with a control mechanism to minimize the amount of water supplied to that needed for immediate use.

2.7 Backflow prevention

2.7.1 The back-up water supply shall be fitted with a backflow prevention arrangement that is capable of preventing the undesirable reversal of flow of non-potable water entering the PUB water (potable or NEWater mains). Flow rates, head loss and installation requirements should be taken into consideration when selecting the backflow prevention arrangement.

2.7.2 No direct connection bypassing the backflow prevention arrangement shall be installed. There shall be no inter-connection or cross-connection between the PUB water supply and the greywater pipes. All Pipes and appurtenances conveying greywater must be labelled and identified clearly.

2.7.3 The backflow prevention arrangement shall comply with the following requirements:

(a) PUB water supply to premises shall be taken through a break tank, to be installed near the PUB meter position.
(b) An air gap of at least 150mm shall be provided between the potable water/NEWater inlet discharge point and the top edge of the treated greywater storage tank.
(c) Double check valves (complying with BS 5153) shall be installed immediately after the tee-off from the potable water/NEWater pipe serving the treated greywater supply tank.

2.7.4 All water service work conveying PUB water shall be carried out by a licensed water service plumber in accordance with the Public Utilities (Water Supply) Regulations and the Singapore Standard CP48, Code of Practice for Water Services. A list of licensed water service plumbers can be found at:
http://www.pub.gov.sg/general/watersupply/LicensedPlumbers/Pages/LicensedPlumbers.aspx

2.7.5 All water pipes and fittings used for the conveyance, storage or use of PUB water shall comply with the standards and requirements stipulated by PUB. These stipulated standards and requirements for various water fittings can be found at:
http://www.pub.gov.sg/general/watersupply/FittingsandStandards/Pages/FittingsandStandards.aspx

2.8 Overflow and Bypass

2.8.1 An overflow shall be fitted to all storage tanks to allow excess greywater to be discharged into the sanitary/sewerage.

2.8.2 The overflow shall be such that any backflow is prevented and vermin are unable to enter the greywater system. Overflows fitted to above ground tanks shall be screened to prevent the ingress of insects, vermin etc.

2.8.3 The size of the overflow pipe shall be equal to or greater than the inlet flow connection pipe to effectively drain-off any excessive inlet flow without compromising the inlet air gap.

2.8.4 The overflow and bypass shall be connected to the sewerage system via floor trap or sump and inspection chamber.

Emergency overflows

2.8.5 The greywater recycling and treatment system shall be provided with emergency overflow pipes which shall be connected to a floor trap for discharging any overflowed greywater to the public sewers.

2.9 Controls and metering

2.9.1 A control unit shall be incorporated in the greywater system to ensure, as a minimum, that users are aware of whether the system is operating effectively.

2.9.2 The control unit shall:

(a) make the user aware when any consumable items need replenishment or replacement, to prevent a system failure;
(b) ensure that treated greywater is not stored for a period that would allow water quality to deteriorate beyond the specified quality or that exceeds the manufacturer's requirements;
(c) in the event of any system failure:
i) make the user aware, e.g. by a visible or audible warning;
ii) ensure that the bypass directs untreated water to the sewer;
(d) in the event of a treatment failure, activate the back-up water supply automatically when required;
(e) control pumps and minimize operational wear and energy use.

2.9.3 In addition to the control unit, system status monitoring shall be incorporated that can inform the user of:

(a) whether treated greywater or back-up PUB water supply is being used;
(b) the volume of treated greywater used and the volume of water used from the back-up PUB water supply. This can be logged and displayed;
(c) how full the tank or cistern is;
(d) any malfunctions. These should relate to the specific fault, e.g. pump failure, back-up PUB water supply failure;
(e) additional monitoring of the overflow, water quality, tank/cistern, temperature and other parameters may also be included.

2.10 Distribution pipes and fittings

2.10.1 Treated greywater shall be delivered to the end users through a parallel network of distribution mains separated from the potable water/NEWater distribution system. For good plumbing practice, it is recommended to make reference to the SS CP48- Singapore Standard Code of Practice for Water Services or other acceptable international standards (e.g. BS8525-1:2010) for the design and installation of the treated greywater distribution pipeworks. Pipes and fittings of equal material, quality and construction for potable water supply system and capable to resist corrosion for the lifetime of the product could be used.

2.10.2 All pipework and fittings, including any below ground pipes, for supply of treated greywater shall be marked and labelled in accordance with Clause 2.11. To differentiate greywater pipework from potable water/NEWater pipework, a contrasting type or colour of pipe material should be used.

2.10.3 The greywater system shall distribute the treated greywater either by:
(a) pumping it from the treated water storage tank directly to the point of use;
(b) pumping it from the treated water storage tank to overhead/roof top supply tank near the point of use;
(c) using a gravity storage tank/cistern, where practicable; or
(d) using a full gravity system, without pumps.

2.10.4 Greywater distribution pipework shall be sized to provide adequate flow and pressure. For example, oversized pipes can cause water quality issues from low flows and excessive pressures can cause undue consumption or leakage.

2.10.5 Greywater distribution pipes shall not be run or laid above any potable water/NEWater pipes. Above ground treated greywater distribution pipes must be at least 100 mm from potable water/NEWater pipes.

2.10.6 Buried greywater main and potable water/NEWater main shall be located at a different depth with a horizontal separation of at least 300mm to provide further protection from having an inadvertent cross-connection occur.

2.11 Signage, Marking and Labelling

2.11.1 All greywater pipes or pipe sleeves and identification tapes shall be labelled **yellow with black stripes** and marked with the following "**GREYWATER – NOT FOR DRINKING OR OTHER POTABLE USES**" at intervals not exceeding 0.5m. Treated greywater outlets (connections, taps, and appliances) shall have signs that are marked "**GREYWATER – NOT FOR DRINKING OR OTHER POTABLE USES**".

This is to:
(a) establish that public health is the overriding concern;
(b) develop construction and design standards;
(c) provide for routine monitoring and surveillance of the non-potable system;
(d) prevent improper or unintended use of non-potable water through a proactive public information program; and
(e) establish and train special staff members to be responsible for operations, maintenance, inspection, and approval of recycling connections.

2.11.2 The measures to prevent improper use or inadvertent use of treated greywater as potable water/NEWater are outlined below:

(a) Identification of Pipes and Appurtenances

All components and appurtenances of the greywater recycling system shall be clearly and consistently identified throughout the system. All equipment and devices (i.e. pipes,

pumps, outlets, and valve boxes) of greywater recycling system, shall be distinctly set apart from the potable water/NEWater system. **Greywater tanks and pumps shall not be sited in the same room/enclosure as potable/NEWater tanks and pumps.**

(b) Greywater Advisory Sign

Valve boxes for hydraulic and electrical components shall be labelled and warnings shall be stamped on the cover.

2.12 Warning Signs

At Toilets:

2.12.1 All installations using treated greywater for flushing of the water closets and urinals shall be identified with signs containing the following text:

"**TO CONSERVE WATER, THIS TOILET USES TREATED GREYWATER TO FLUSH WATER CLOSETS AND URINALS"**

2.12.2 Each sign shall contain letters of a highly visible colour on a contrasting background and the sign shall be visible to all users.

At Equipment Rooms:

2.12.3 Each equipment room containing greywater recycling system shall have signs posted with the following text in a location that is visible to anyone working on or near greywater recycling system:

"**CAUTION: GREYWATER - NOT FOR DRINKING OR OTHER POTABLE USES. DO NOT CONNECT TO DRINKING WATER SYSTEM."**

"NOTICE: CONTACT BUILDING MANAGEMENT BEFORE PERFORMING ANY WORK ON THIS GREYWATER SYSTEM"

At Storage Tank:

2.12.4 Each storage tank shall be labelled: "**GREYWATER - NOT FOR DRINKING OR OTHER POTABLE USES"**

2.13 Security

All greywater treatment facilities, pumps, valves and controls shall be locked, fenced or enclosed as necessary to prevent unauthorised access or interference.

PART 3 Testing and Commissioning

3.1 General

3.1.1 The greywater recycling system shall be commissioned in accordance with the system specifications & design and the manufacturer's installation and commissioning manual.

3.1.2 In all cases, the following tests shall be undertaken prior to commissioning and hand over to the user.

(a) The collection pipework of the greywater system shall be inspected and tested for water and air tightness to ensure that the collection pipework of the greywater system is leak-free and that there are no unintentional cross-connections.

(b) The distribution pipework of the greywater system shall be inspected, flushed and dye-tested (in accordance with Clause 3.2) to ensure that pipework and containers are watertight and that there are no cross-connections with any potable water/NEWater supply.

(c) The distribution pipework and fittings of the greywater system shall be pressure tested. The test pressure shall be at a minimum of 1.5 times the maximum working pressure under normal operating conditions.

(d) The back-up PUB water supply (potable water or NEWater) system shall be inspected & tested to ensure no cross-connection. A standard bacteriological test shall be performed on the drinking water sample to ensure drinking water is not contaminated.

3.1.3 After testing, the greywater recycling system shall be thoroughly flushed to remove all residual traces of colourant before it is commissioned and put into operation.

3.1.4 Before supplying treated greywater for the intended use, samples of the treated greywater shall be taken and tested to confirm compliance with the treated greywater quality requirements specified in Table 1, Part 4 of this Guide.

3.2 Dye testing for distribution pipework cross-connections

(Reference may be made to the British Standard BS 8525-1-2010 Clause 5.5.2 Figure 3 for more details for the cross-connection dye test)

3.2.1 Testing for cross-connections shall be carried out before final connections to the back-up PUB water supply are made, as follows.

(a) The greywater treatment unit and back-up PUB water supply pipe shall be disconnected and capped prior to testing.

(b) All in-line servicing and stop valves shall be opened on both the back-up PUB water supplies and the greywater system. The stop valve on the back-up PUB water supply shall be closed.

(c) The greywater system shall be filled with clean potable water/NEWater and a suitable colourant, such as cochineal E124, added. Water shall then be drawn through the greywater system until coloured water exits at the points of use. Outlets on the back-up PUB water supply shall be systematically opened to check that no coloured water is discharged.

(d) If any coloured water is discharged from a back-up PUB water supply outlet, the cause shall be investigated and rectified.

PART 4 Treated Greywater Quality for Non-potable Use

4.1 Water Quality Requirements for Treated Greywater

4.1.1 In order to protect public health and the environment, the physical and microbiological quality of the treated greywater shall meet the treated greywater quality requirements specified in the **Table 1** below at the outlet from the treatment plant and after the treated greywater storage tank.

4.1.2 Treated Greywater shall only be used for the following applications:
(a) Flushing of Water Closet (WC)/Urinal.
(b) General washing (excluding high pressure jet washing and general washing at markets and food establishments).
(c) Irrigation (excluding irrigation sprinklers).
(d) Cooling Tower make up water.

Table 1: Requirements for Treated Greywater Quality for Recycling

No.	Parameters	Unit	Requirements for Treated Greywater Quality for Recycling	Applicable to
1	Odour		Non offensive	toilet flushing, general washing*, irrigation* and cooling tower make up
2	Colour	Hazen Units	<15	
3	pH		6-9	
4	Total Residual Chlorine	mg/l	0.5-2.0	
5	Turbidity	NTU	<2	
6	BOD_5	mg/l	<5	
7	Total Coliform	CFU/100 ml	<10	
8	*E Coli*	CFU/100 ml	N.D.	
9	Standard Plate Count / Heterotrophic Plate count (SPC/HPC)		<500 CFU/ml	cooling tower make up only
10	Total *Legionella* count		Non-detectable when tested using the latest ISO 11731, BS6068-4.12, or equivalent method that is able to test total *Legionella* count at or below 1000 CFU/L	cooling tower make up only

N.D: Not Detectable

*Note: Use of treated greywater for high pressure jet washing, irrigation sprinklers and general washing at markets and food establishments is not allowed to minimise risks and public health concerns.

4.1.3 The above-mentioned requirements are intended to present a set of common parameters that shall be considered while evaluating the quality of treated greywater. However, in certain circumstances, use of specific chemicals or agents at the site and/or the nature of treatment process may require additional parameters to be considered while evaluating and monitoring the quality of treated greywater. In addition, the greywater may also contain surfactants/wetting agents, antimicrobial agents, emollients, etc. If these substances are not adequately removed, the treated greywater may give rise to foaming problems and/or may appear to be coloured or turbid, which may adversely affect the users' perception of the quality of treated greywater.

4.2 Sampling Frequency

Minimum sampling frequency is indicated in **Table 2** below and shall be strictly followed.

Table 2: Minimum sampling regime and monitoring frequency for treated greywater

No.	Parameters	Toilet flushing, general washing, irrigation	Cooling Towers
1	Odour	Non offensive at all times	Non offensive at all times
2	Colour	Monthly	Monthly
3	pH	Monthly	Continuous online
4	Total Residual Chlorine	Continuous online	Continuous online
5	Turbidity	Monthly	Continuous online
6	BOD_5	Quarterly	Quarterly
7	Total Coliform	Monthly	Monthly
8	E Coli	Monthly	Monthly
9	SPC / HPC	NA	Monthly
10	Total Legionella count	NA	Quarterly

Note: Necessary sampling points (minimally at the treated greywater tank outlet) shall be installed so that sampling can be carried out at the above-mentioned frequency.

The testing of water samples shall be done by Singapore Accreditation Council (SAC)-SINGLAS accredited laboratories accredited for general water quality testing.

PART 5 Maintenance and Risk Assessments

5.1 General

It is the responsibilities of the property owners and the appointed operator to ensure that the onsite greywater recycling system is used sustainably and operated appropriately according to system specifications/design. They should familiarize themselves with the type of system in place, the system's location, as well as its performance. A good and regular maintenance and monitoring programme is essential to ensure proper functioning of the greywater recycling system.

5.2 Quality Requirements for Greywater Recycling System

Greywater treatment systems with associated recycling systems shall be managed to operate reliably and consistently in order to ensure a quality controlled treated greywater is eventually supplied for use. Some measures to achieve a quality controlled treated greywater system include:

- Implementation of "at source" pollution reduction such as trade waste controls;
- Reliable and consistent treatment processes;
- Safeguarded disinfection systems;
- Secure distribution systems;
- Qualified and trained operators and caretakers;
- Continual improvement of performance, maintenance, inspection monitoring and reporting programs; and
- Contingency plans for system failures.

5.3 Post-commission Monitoring programme

Property owner and operator of greywater recycling system have a responsibility to implement a planned program for monitoring and recording performance following commissioning of the greywater recycling system. Collected data is to demonstrate to the user that the treated greywater quality is suitable for the intended use and will quickly highlight any problems with the greywater treatment system and allow corrective / remedial action to be taken. To ensure that remedial action can be taken early, the following are recommended:

(a) flow monitoring (feed flow and treated water flow);
(b) greywater quality monitoring at system outlet;
(c) treated greywater quality monitoring; and
(d) daily checking of the disinfection system by measuring chlorine consumption in the tank.

5.4 Operation & Maintenance

5.4.1 Inspection & maintenance of the parts and components (e.g. filters, membranes, biological & disinfection systems), pumps and pump controls, control units, backwash, etc shall be in accordance with the design & manufacturer's operation and maintenance recommendations.

5.4.2 Even with sufficient chlorination, residual organics and bacteria may grow at dead spots in the system, which may lead to odour and clogging problems. The greywater system shall be drained and flushed with clean water periodically to reduce the risk of contamination.

5.4.3 Maintenance requirements for the back-up PUB water supply (potable water or NEWater) system shall be the same as those for potable water system outlined in CP48.

5.4.4 The greywater treatment system shall be maintained by an authorised service contractor in accordance with the manufacturer's specifications. A minimum annual inspection is required to be conducted as part of the maintenance requirements.

5.5 Self-Monitoring of treated greywater quality

5.5.1 Regular monitoring of treated greywater quality shall be followed strictly in accordance with the sampling frequency described in Clause 4.2, Table 2 of this Guide.

5.5.2 During commissioning stage more frequent samples (weekly) should be tested. Later after three months of operation, the frequency shall be reduced according to the sampling frequency. All abnormalities on treated greywater quality shall be properly documented and kept with the owner. Where a membrane-based treatment is used, the site management shall implement a regular cleaning/maintenance programme, and shall periodically check the integrity of the membranes as recommended by the membrane manufacturer/supplier.

5.5.3 Water sampling for tests shall be done immediately following any reports of illness that could be deemed to be associated with water use from the greywater recycling system. Tests shall be undertaken to investigate the cause of any system that is not operating satisfactorily.

5.5.4 If levels of the bacteriological parameters exceed the guideline value in Clause 4.1, Table 1, the use of the greywater recycling system shall be suspended until the problem is resolved.

5.5.5 If the level of the total residual Chlorine parameter does not meet the treated greywater quality requirements as mentioned in Table 1, Part 4, the use of the greywater recycling system shall be suspended until the problem is resolved.

5.5.6 For the other parameters that do not meet the requirements as mentioned in Table 1, Part 4, tests shall be undertaken to investigate the cause. Following completion of the remedial works, one sample shall be taken at each sampling points (i.e. at treated greywater storage tank and point of use) for retesting the treated greywater quality. If the levels still do not meet the requirements as mentioned in Table 1, Part 4, the use of the greywater recycling system shall be suspended until the problem is resolved.

5.5.7 All the treated greywater in the storage tanks that does not meet the requirements as mentioned in Table 1, Part 4 shall be drained out and discharged directly into the sanitary/sewerage system.

Sample points

5.5.8 Water samples shall be collected from locations that best represent the whole system status, i.e. the point of use(s) and from treated greywater storage tanks.

5.5.9 Where more than one tank or cistern is used in the system, samples shall be taken from:
(a) the most upstream storage tank, to test the quality of the treated greywater;
(b) any subsequent tanks/cisterns if the stored greywater is likely to be either affected by temperature variations (e.g. in a loft) or mixed with water from the back-up PUB water supply.

5.6 Public Health Risk assessments

5.6.1 A public health risk assessment shall be carried out to determine whether the greywater system is safe and fit for purpose. The risk assessment shall consider the design, installation, testing and commissioning, operation and maintenance of the greywater system, including water quality.

5.6.2 The risk assessment shall consider the effects of exposure to and the potential impacts of, the water within the greywater system and any of the system's treatment processes on:
(a) people, including operators, installers, maintainers, and water users, particularly those who might be more susceptible to poor water quality (e.g. children or the elderly);
(b) the environment, including domestic and feral animals, birds and fish, plants, water courses and groundwater;
(c) physical assets, including buildings, building fabrics, room decorations and, where external tanks are used, foundations, drains, paved areas and gardens.

The risk assessment shall be used to identify and evaluate potential hazards, and the necessary mitigation measures, e.g. additional actions, process improvements or enhanced controls that can reduce risks to a minimum in an effective and cost-effective manner. The risk assessment shall consider potential sources of contamination of water entering or already in the greywater system. The risk assessment shall be used to identify the need for any further water quality control measures, including additional monitoring.

Part 6 References and Guides

Annex 1 - Typical physical, chemical and microbiological quality of greywater

(a) Physical and Chemical Quality

There is a high amount of variability in the chemical and physical quality of greywater produced by any building, due to factors such as the source of water, the water use efficiency of appliances and fixtures, individual habits, products used (e.g. detergents, shampoos, soaps, etc) and other site-specific characteristics.

The amount of salt (sodium, calcium, magnesium, potassium and other salt compounds), oils, greases, fats, nutrients and chemicals in greywater can largely be managed by the types of products used within a building.

Table 1 below gives typical physical and chemical parameters measured in raw greywater.

Table 1: Typical physical and chemical parameters measured in raw greywater

Parameter	Unit	Raw greywater (range)
Suspended Solids	mg/L	10-100
Turbidity	NTU	20-100
BOD_5	mg/L	50-150
Ammonia	mg/L	1-10
Total Phosphorous	mg/L	0.5-5
Sulphate	mg/L	10-50
pH		6.5-8.5
Total Hardness as $CaCO_3$	mg/L	30-150
Conductivity	µs/cm	150-500
TOC	mg/L	50-100

(b) Microbiological Quality

The Escherichia coli (E.Coli) group of bacteria are used as an indicator of microbiological quality. E.coli belongs to the thermotolerant faecal coliforms group. They are a type of microorganism, which typically grow in the intestine of warm-blooded animals (including humans) and are shed in their millions in each gram of faeces. Occurrence of E.Coli in greywater indicates a risk of pathogens being present and hence, the risk of contracting illness or infection through contact with the water.

When untreated greywater is stored, it will turn septic, giving rise to offensive odours and providing suitable conditions for microorganisms to multiply. Thermotolerant coliforms multiply between 10 and 100 times during the first 24 to 48 hours of storage. Therefore, untreated greywater must only be stored temporarily, for less than 24 hours, in a surge tank.

Microbiological hazards have been identified as the source of risk to human health from the use of greywater. Human enteric pathogens can be found in water contaminated by human waste and may be washed into greywater during hand washing, bathing, showering and clothes laundering. In conditions

of high levels of biodegradable carbon and warm temperatures, such as might be found in greywater storage, opportunistic pathogens such as *Pseudomonas aeruginosa* and *Aeromonas* spp. could conceivably grow, whereas biofilms in water pipes have been shown to allow the growth of *Legionella* spp. and *Mycobacterium avium.*

Table 2 shows the wide range in the concentration of indicator bacteria that may be found in greywater.

Table 2: Concentration ranges of indicator bacteria reported in untreated greywater[a]

Concentrations (CFU/100mL)				
Source of greywater	**Total coliforms**	**Thermotolerent coliforms**	**Escherichia coli**	**Faecal enterococci**
Hand wash basins	$2.4x10^2$-$>2.4x10^6$	n.a.[b]	$0 – 2.4x10^6$	$0 – 2x10^4$
Bath/showers and hand basins	$2.5x10^2$ -$1.8x10^8$	$0-5.0x10^3$	$10 - 10^5$	$10 - 10^5$
Laundry, kitchen sinks	$7x10^5$	$7.3 x10^2$	n.a.	n.a.
Greywater[c]	$10^2 - 10^6$	$10^2 - 10^6$	$10 - 10^5$	n.a.

(a) From Gardner (2003), Koivunen et al. (2003), Lazarova et al. (2003), Ottoson and Stenstrom (2003), Birks et al. (2004), FBR (2005) and NRMMC-EPHC (2006).
(b) n.a. = not available.
(c) Wastewater from all domestic sources, excluding the toilet and kitchen sink.

(c) Nutrients

Greywater contains nutrients generated from the bathroom and laundry. By managing the type and amount of washing detergents, personal hygiene products and cleaning agents that are used, the amount of nutrients in greywater can be managed.

(d) Salts

Salts in greywater originate from washing detergents and are commonly in the form of sodium, magnesium and calcium compounds.

Annex 2 - Types of Greywater Treatment Systems

There are many treatment processes that can remove contaminants from greywater to varying degrees, depending on the intended final use of the treated greywater. Greywater should only be treated to a level that matches its intended non-potable use, to avoid unnecessary treatment costs.

The treatment of used water is usually performed by a combination of biological, physical and chemical processes. Biological treatment uses microorganisms in suspension in the wastewater or attached onto a support media, to assist in the removal of matter from the wastewater. Physical treatment removes the waste by filtration through a granular media or through a solid media, such as membrane filtration. Chemical treatment involves adding specific chemicals to precipitate targeted components or adsorbing them onto a media. All of these processes can provide different degrees of treatment.

(a) Microfiltration, Ultrafiltration and Nanofiltration

Microfiltration can be used to remove bacteria, protozoa and small suspended solids or to clarify liquids. When combined with post-filtration disinfection by UV, this is a very effective technology for virus removal, as it removes the particles that can shield viruses from UV radiation. Microfiltration is the most commonly used type of membrane filtration, either alone or as a pre-treatment for reverse osmosis. Most microfiltration membranes have a pore size of 0.1 microns. Particles in this size range, such as bacteria, are retained and concentrated by the membrane.

Ultrafiltration or nanofiltration can be used to reduce the BOD of wastewater, separate oil from used water and remove natural and synthetic organics, disinfection by-products and multivalent inorganic substances (e.g. water softening by removing calcium and magnesium). Ultrafiltration membranes have a pore size of 0.01 microns while nanofiltration membranes have a pore size of 0.001 microns. Molecules such as proteins and sugars are in this size range. Ultrafiltration or nanofiltration is also very effective at reducing pathogens.

(b) Membrane Bioreactors (MBR)

Membrane bioreactors combine conventional biological treatment with membrane separation to produce very high quality treated greywater. Treatment plants are very compact and have low requirements for operator attention compared with conventional treatment plants. MBR packaged units also save space requirements.

(c) Biologically Activated Carbon (BAC) Filtration

Filtration of greywater through biologically activated carbon can remove many contaminants, including pesticides and herbicides, pharmaceuticals, disinfection by-products and cyanobacterial toxins. The effectiveness of activated carbon filters to adsorb organic chemicals can be enhanced by treating the water with ozonation to breakdown large organic compounds to smaller organic particles. Activated carbon filters are thermally regenerated by burning off the contaminants, after which they can be reused.

(d) Dissolved Air Flotation

Dissolved air flotation (DAF) involves injecting air into water, forming very small bubbles that attach to floc particles formed by addition of a chemical flocculant. Solids then float to the surface to be skimmed off. When combined with appropriate disinfection, DAF can produce high quality treated greywater.

Annex 3 - Types of Disinfection of Treated Greywater

Disinfection is an essential treatment component of greywater recycling system to ensure that treated greywater is fit for use. Among the disinfection options available for greywater are chlorine containing chemicals like sodium hypochlorite, chlorine dioxide, UV radiation, membrane filtration, and advanced oxidation processes involving use of ozone or hydrogen peroxide. Each of these has advantages in different circumstances, and in many cases a combination of these approaches is best for disinfecting greywater.

All disinfection systems shall be automated with alarms and automatic shut-off of the treated greywater supply in case of failure. Effective maintenance and a quality assurance system would minimise the risk of treatment failure. All chemicals used in the greywater recycling systems for the treatment and water testing purpose shall be used, handled and stored in accordance with the relevant regulations and guidelines issued by the Ministry of Manpower, National Environment Agency, and other government agencies.

The site management shall also take all applicable measures to protect workers and other personnel from any hazard that is likely to endanger their safety and cause adverse health effects. One such measure is to ensure that chlorine-containing chemicals are stored separately with adequate segregation and measures to prevent accidental mixing with acidic chemicals.

(a) Chlorination

Chlorine for disinfection of greywater has to be done carefully. The chlorine dose and contact time required to ensure adequate disinfection of greywater will depend on the characteristics of the greywater (e.g. pH, BOD and TSS), the chlorine demand (determined by the presence of organic matter, ammonia, iron and manganese) and the final uses of the treated greywater (e.g. whether a residual is required). Also, there can be problems in measuring free versus available chlorine in greywater due to the formation of chloramines following the reaction of chlorine with ammonia in the effluent. This means that no single figure for free or total chlorine can be specified for chlorine disinfection of greywater.

As with some other disinfectants, chlorine produces disinfection by-products in reaction with organic and inorganic substances usually present in greywater. The level of these by-products varies with the chlorine dose and the level of free chlorine in the greywater.

Due to the presence of organics and other substances in the greywater, the chlorine demand would vary, when chlorination is practised. Also, at high pH, chlorine will not be effective as a disinfectant. These factors, together with the contact time for chlorine, shall be considered while designing the treatment programme for greywater recycling systems. The treatment programme should ensure that disinfection is carried out effectively.

Also, chlorine is relatively ineffective at inactivating some pathogens, such as Cryptosporidium oocysts, and the residual chlorine can be toxic to sensitive organisms if it is released into the environment during final use of treated greywater. When this potential for toxicity must be reduced, de-chlorination may be required.

(b) Ultraviolet radiation

Ultraviolet radiation is an effective disinfection process that does not produce by-products that may be toxic to humans or the receiving environment. UV dose is a product of UV intensity and exposure time and is expressed as milliwatt seconds per square centimetre ($mW.s/cm^2$). UV achieves disinfection by initiating a photochemical reaction that damages the DNA molecule within micro-organisms, so that

cell division and consequently multiplication can no longer occur. The amount of cell damage depends on the dose of UV energy absorbed by the micro-organisms and their resistance to UV.

UV disinfection is only effective with greywater that has low suspended solids, turbidity and colour. A chemical residual, such as chlorine, may be required after UV disinfection to limit bacterial re-growth within the distribution system.

(c) Oxidation processes

There are many oxidation processes that can be used for treatment and disinfection of greywater, the more common of which use ozone, chlorine dioxide or hydrogen peroxide. The most commonly used process is ozonation. For indoor premises, the level of ozone should not exceed the guideline stated in the Singapore Standard 554.

A disadvantage of ozonation is that it produces small quantities of disinfection by-products that may be hazardous to human health when ingested or inhaled in sufficient quantities. In addition, ozone gas is extremely toxic so ozone generating facilities must be managed in accordance with appropriate workplace health and safety provisions. If ozone-treated greywater has a significant amount of residence time in pipes, it is also likely to require chlorine residual to prevent microbial re-growth.

Annex 4 Greywater Dos & Don'ts

Dos:

- ✓ Minimize human and animal contact with greywater; always wash your hands after contact.
- ✓ Ensure that PUB water supply is isolated from the greywater system, with no cross-connection of any form.
- ✓ Ensure that greywater tanks and pumps are not sited in the same room/enclosure as potable/NEWater tanks and pumps.
- ✓ Label pipes conveying greywater clearly to ensure that there is no confusion between greywater and potable water/NEWater is possible.
- ✓ Label pipes, tanks and other fittings storing/conveying greywater clearly to ensure that there is no confusion between greywater and water supplied by PUB.
- ✓ Label the devices (in which the treated greywater is used) clearly to show that the water used in such devices is not for potable use.
- ✓ Use greywater only for intended non-potable use.
- ✓ Ensure that alternatives (e.g. back-up PUB water supply or back-up power and treatment modules) are available in the event of power failures, overflows, equipment failure or maintenance shutdowns, and that for the back-up PUB water supply:
  - Ensure that the PUB water supply to premises is taken through a break tank, to be installed near the PUB meter position.
  - Ensure that an air gap of at least 150mm is provided between the potable water/NEWater inlet discharge point and the top edge of the treated greywater storage tank.
  - Ensure that double-check valves (complying with BS 5153) are installed immediately after the tee-off from the potable water/NEWater pipe serving the treated greywater storage tank.
  - Ensure that there is no inter-connection between the PUB water supply pipes and the greywater pipes
- ✓ Ensure that all water service work conveying PUB water is carried out by a licensed water service plumber in accordance with the Public Utilities (Water Supply) Regulations and the Singapore Standard CP48, Code of Practice for Water Services.
- ✓ Ensure that all water pipes and fittings used for conveying PUB water shall also comply with standards and requirements stipulated by PUB which can be found at http://www.pub.gov.sg/general/watersupply/FittingsandStandards/Pages/FittingsandStandards.aspx
- ✓ Mosquito-proof the water storage tanks in accordance with the "Guidelines on Mosquito Prevention in Domestic Rainwater Collection System for Non-Potable Uses" (available on NEA's website)
- ✓ Ensure that the treated greywater does not contain harmful agents that cause infectious disease or endanger public health through human exposure by direct contact, ingestion or inhalation.
- ✓ Ensure that all the used greywater if it is not recycled for reuse, to be discharged into the public sewer.
- ✓ Ensure that the disposal of unused greywater to be flowing into the public sewer.

Don'ts:

- × Allow hazardous chemicals, such as oils, solvents, pesticides, etc into your greywater recycling system.
- × Allow diaper wash water or similarly soiled or infectious garments into the greywater recycling system.
- × Allow greywater to flow from your property or to enter stormwater drain.