Green Building Handbook for South Africa
Chapter: Water Conservation

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1 Water conservation

1.1 Introduction

Clean water is becoming an increasingly scarce commodity. Green buildings aim to develop systems to minimise the consumption and pollution of this resource. Careful design is used to develop rainwater harvesting, plumbing and ecological sanitation systems that enable buildings to be self reliant for their water needs and avoid polluting water. This reduces the requirement for large-scale water and sanitation infrastructure that consumes energy and can be highly wasteful.

This chapter describes water systems used in green buildings and sets out some objectives that could be aimed for. It also outlines some calculations that can be used to design water systems in green buildings. Finally, aspects of green building water systems are described, so that designers can select, and work with, the most appropriate of these to develop high performance sustainable water systems in buildings.

1.2 Water in green buildings

Water systems in green buildings are different in a number of ways from conventional buildings. A number of these characteristics are described below.

- **Self sufficiency:** Green buildings aim to meet all, or most of their water needs from rainwater harvesting.
- **Water quality:** The quality of water is matched with use. For instance, the best quality water may be used for drinking and cooking and poorer quality water, such as grey water, used for flushing toilets and irrigation.
- **Onsite retention:** In natural environments vegetation and soil absorb and retain a large proportion of rain water that falls on to it. Green buildings aim to emulate this by ensuring that buildings and sites absorb and retain rain water on site and avoid generating large quantities of run off.
- **Evaporation and transpiration:** Air can be cooled and the humidity increased through evaporation of water and transpiration from plants. This may be used in green buildings to improve comfort levels without the use of mechanical systems.

1.3 Key performance objectives

Some performance objectives for green building water systems are provide below.

Aspect	Performance Objective	Achieved?
Potable water consumption	Buildings consume 50% less mains potable water compared to conventional buildings.	
Rainwater harvesting	Buildings meet at least 40% of its water requirements from rainwater harvesting	
Hand basin taps	Hand wash basin taps specified have flow rates lower than 6L/minute	
Showerheads	Showerheads specified have flow rates lower than	

	10L/minute	
Toilets	Toilets specified have no or low water requirements. Consumption does not exceed 4.5L for ½ flush and 9L for full flush.	
Storm water runoff	The amount of runoff from a site may not be increased as a result of development. In addition the quality of the water is not be negatively affected.	
Planting	Planting specified requires little or no irrigation unless planting is for food production.	
Large water consuming equipment	Equipment and facilities, such as swimming pools, with large water consumption requirements are avoided. If this is not possible, they are made as water efficient as possible by using rainwater harvesting, water recycling and minimizing evaporation.	

1.4 Working with water systems

There are a number of calculations that can be used to design water efficient systems and rainwater harvesting systems for buildings. These are described below. It should be noted that calculations shown below have been simplified to aid understanding. More detailed calculations with appropriate margins should be carried out as part of a detailed design process.

1.5 Potential rainwater harvesting capacity

The potential rainwater harvesting capacity of a roof can be calculated by multiplying the area of the roof by the annual rainfall. Thus a house with a 100m2 roof in an area with 500mm annual rainfall has an annual rainfall harvesting capacity of 50,000L, as indicated below. There are however losses from evaporation as rain falls on to hot roofs and this may reduce the amount harvested by up to 10%, reducing actual capacity to 45,000L.

Area of roof (m2)	**Annual rainfall (mm)**	**Potential rainfall harvesting capacity (L)**	**Actual rainfall harvesting capacity (L)**
100	500	50,000	45,000

1.6 Water consumption

Water consumption in buildings can be calculated by multiplying the quantity of water used by different water consuming devices in a building by the number of times these are used, as indicated in the table below.

Water consumption device	**Water consumption (L)**	**Number of uses per day**	**Water consumption (L)**
Flush toilet	9	8	72
Hand basin	3	8	24
Showers	40	4	160
Washing / cleaning	20	3	60
Water consumption per day			316
Water consumption per month			9,796

It should be noted that flush toilets and conventional water delivery devices have been used for the calculations above and that these figures can be reduced through use of waterless toilets and more efficient devices.

1.7 Grey water generation and consumption

Grey water is waste water from wash hand basins and showers. Using the table above the production of grey water can be calculated. Here, the grey water production is 24L (hand basins) and 160L (showers) giving a total of 184L/day. The water consumption of the flush toilets are considerably below this at 72L/day indicating that there should be sufficient grey water capacity that can be used to flush toilets, with the excess being used for irrigation.

Using a grey water system here would result in a reduction in water consumption of 72L/day, or a 25% reduction in water consumption in the building. This can be factored into the sizing or rainwater harvesting tanks indicated below, to provide a larger margin or to allow for a reduction in tank size.

1.8 Rain water harvesting tanks

There are a number of different ways of sizing rainwater harvesting systems. The most practical way is to calculate average water consumption in your building and multiply this by the longest dry period. This is indicated below.

Number of months with low or no rainfall	Consumption (L)	Required capacity (L)
4	10,000	40,000

A contingency should always be allowed as rainfall can be highly variable with coefficients of rainfall variation in deserts around 200%, in semi-arid areas 40%, and in humid areas 5-13% (SARPN Position paper on water and sustainable development). Thus, in desert areas you may allow for a contingency margin of 200%, whereas this may be 10% in a humid area. This approach is suitable for buildings which aim to be self sufficient.

However even fairly modestly sized rainwater tanks can make a significant contribution to reducing mains potable water consumption. This is indicated in the table below.

Month	**Rainfall (mm)**	**Rainfall harvested (L)**	**Monthly consumption (L)**	**Additional mains water required (L)**
January	82	8,200	10,000	1,800
February	60	6,000	10,000	4,000
March	52	5,200	10,000	4,800
April	33	3,300	10,000	6,700
May	11	1,100	10,000	8,900
June	5	500	10,000	9,500
July	3	300	10,000	9,700
August	6	600	10,000	9,400
September	17	1,700	10,000	8,300
October	43	4,300	10,000	5,700
November	85	8,500	10,000	1,500
December	81	8,100	10,000	1,900
Totals	**478**	**47,800**	**120,000**	**72,200**

This shows that the building is nearly self sufficient in water for 3 months of the year (November, December and January). It also shows that the 10,000L rain water tank has the effect of reducing mains water consumption by 47,800L or by about 40%.

1.9 Aspects of water systems

There are a number of aspects and components of water systems in buildings that can be used to ensure to achieve green building objectives. These are described below.

1.10 Water meters

The mains water meter in a green building should be located where this can be easily read, in order to monitor consumption. In addition, sub metering should be provided for areas with substantial water requirements such as large irrigation systems. This allows water consumption to be monitored more closely, and controlled.

1.11 Water pressure

High water pressure can result in wastage as flow rates of taps and showers are increased. Correct water pressures should therefore be specified and pressure reducing valves used, if necessary.

1.12 Wash hand basin taps

Large quantities of water can be wasted when taps are left running. This is often the case in wash hand basin taps. To reduce wastage the following measures can be taken:

- **Flow rates:** Taps with flow rates of under 6L/minute should be specified. Where flow rates are higher than this, constrictors and aerators can be used to reduce flow rates.
- **Usage:** The length of usage can also be controlled through metering and demand taps or taps fitted with proximity sensors.

1.13 Showers

Where possible, baths should be avoided and showers, which use less water, should be specified. The specification of showerhead and controls can support efficiency in the following ways:

- **Flow rate:** Maximum flow rates of 10L/minute should be specified for showers.
- **Usage:** Usage can be controlled by shower valves that control the amount of water that is used

1.14 Hot water pipes

Large amounts of water are wasted when people run taps waiting for water to become warm. This wastage can be reduced by minimising the length of piping from the point at which water is heated to where it is used. Therefore solar water heaters and geysers should be located as close as possible to areas where hot water will be consumed. In addition, hot water pipes should be insulated to ensure that water in the pipe is still warm when the hot water taps are next switched on.

1.15 Toilets

Toilets which require large amounts of water should be avoided. Ideally, toilets that do not require any water, such as composting toilets, should be used. However, if this is not possible, toilets that use the minimum amount of water possible should be used. This can be achieved through specifying low flush toilets which do not require more than 9L/flush or through dual-flush mechanisms that enable users to use a half flush, of say of 4.5L, when full flushes are not required.

1.16 Urinals

Waterless urinals have become increasingly popular in green buildings. These use valves or chemicals to avoid using water to flush urinals and can result in significant water consumption savings. It is however important to understand, and address, the maintenance requirements of this equipment to ensure that this remains effective. Where water is used for flushing urinals, highly efficient devices should be specified, and flush rates set as low as possible.

1.17 HVAC systems

HVAC systems that require large amounts of water should be avoided. If systems that require water are used the water for these should be obtained from rainwater water harvesting.

1.18 Water consuming devices

Large water consuming devices such as swimming pools and large ornamental ponds should be avoided as their water consumption requirements as a result of evaporation can be high. If however, these cannot be avoided, they should be replenished from rainwater storage and covered when not is use to reduce evaporation.

1.19 Planting

Planting should be carefully specified to avoid large requirements for water. Indigenous planting and dry climate plants as aloes and succulents with low water requirements may not need irrigation at all. Clustering plants with different water requirements can also reduce water consumption as irrigation is minimised.

1.20 Water efficient irrigation

Where irrigation is used this should be as efficient as possible and be fed from rainwater harvesting. Drip or subsurface irrigation is water efficient and minimises losses as a result of evaporation. Further reductions can be achieved through soil moisture meters and timers which ensure that irrigation occurs only when needed and happens at night when losses from evaporation are lowest.

1.21 Grey water

Grey water comes from showers, hand basins and ater from toilets, kitchens sinks and dishwashers is dangerous for human health should never be used in grey water systems. Both proprietary and simple grey water systems can be used to reduce potable water consumption. Proprietary systems have sophisticated filters which sterilize water and remove sediment and dirt. Simple grey water systems may partially filter water and direct this to toilets for flushing or to landscapes where it is used for irrigation.

A key consideration in the design of grey water systems is that grey water turns into black water if allowed to stagnate. Therefore grey water should be used soon after it has been produced and never stored unless this has been properly treated. Because of the potential health hazards grey water specialists should be consulted in the detailed design of a system.

1.22 Waste water treatment

Grey water from buildings can also be treated and filtered on site using reed beds and reused or allowed to replenish groundwater. This reduces the requirement for large-scale sanitation infrastructure and provides an additional source of water which can be used for irrigation. Wetlands can be constructed or proprietary systems used.

Wetlands use micro organisms living in reed beds to clean water and the variety of plant and animal life supported can add substantially to the ecological value of a site.

1.23 Rainwater harvesting

The rain water calculations above indicate that even in dry climates rain water harvesting can enable buildings to be totally self sufficient in water. They also show that even relatively small rainwater tanks can make a significant contribution to reducing mains portable water consumption. Rainwater harvesting systems should therefore be a central strategy in green buildings. Considerations that should be taken into account are listed below.

- **Location:** Large rainwater tanks may result in significant structural loads. It is often therefore appropriate to locate these underground or in a basement in the building. The high thermal mass of the water can also be used as part of a building's thermal strategy. For instance, rain water tanks located on East and West facades will absorb heat from the sun reducing heat gains in the building.
- **Filters:** Dust and other debris may accumulate on roof surfaces (particularly on flat roofs). To avoid this contaminating stored rain water a filter or tipping mechanism should be used to direct the first runoff from the roof away from the tank. Once the roof and gutters have been flushed clean, water can then directed to tanks.
- **Harvesting areas:** It should be noted that rainwater can be harvested from a range of surfaces as well as roofs. Therefore, if there is a need for additional water runoff from landscapes, paved areas and parking can also be used. Additional care may be needed here to avoid contamination from sediment and oil and fuel spills. This can be addressed through proprietary filter and oil traps as well as permeable paving systems (see below).
- **Maintenance:** The design and specification of rainwater tanks should take management issues into account such as the lifespan of the tank and the maintenance regime required to ensure that water remains clean and does not become a breeding ground for mosquitoes etc.
- **Building plumbing:** Rainwater tanks should be integrated into a building's plumbing system to ensure that effective use of stored water is made. It should be noted that rainwater tanks provide a very useful backup supply of water for fire fighting and for times when the mains supply is not be available. This can help justify the costs of larger rainwater tanks.

1.24 Permeable paving

Permeable paving can be used to enable rainwater to be absorbed into the ground and reduce runoff from a site. Permeable paving combined with sub-base layers may also be used to filter and store rainwater. The detailed design of these systems should be carried out with a specialist, particularly if there are unknown or sensitive geological conditions.

1.25 Onsite retention of rainwater

Green building sites aim to retain as much rainwater on site as is possible. This can be harvested for use in the building or used to replenish groundwater. Replenishing ground water reduces the requirement for irrigation, and the moisture from soil and plants humidify and cool air. It may be difficult in highly built-up sites, or sites with large areas of hard surfaces to minimise runoff. Outlined below are a number of techniques that can be used to maximise onsite retention:

- **Retention ponds:** Rainwater can be directed to retention ponds where it can be used for irrigation and other uses.
- **Permeable paving:** Permeable paving can be used to reduce or eliminate

runoff (see above)

- **Swales and basins:** Swales and basins are grassed areas that used to slow down and store surface runoff. These encourage infiltration of water into the ground and help reduce peak runoff flows.