Conserving Water
in Further Education Colleges

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FOREWORD

This guide is a product of ***Building for the Future*** - an inter-regional collaboration, part-funded by the GROW EU Interreg3C joint programme, which aims to achieve balanced and sustainable economic growth.

The purpose of this guide is to empower colleges to make informed decisions with regard to water conservation.

By reviewing some of the issues involved in water usage and sustainable construction, we hope to assist colleges in the formulation of appropriate water conservation strategies, and to justify the use of sustainable construction techniques.

Every construction project has its own challenges, but the impetus is towards reducing the environmental impact of buildings, both as they are built and as they are used.

AOSEC is very grateful to the partners that have been such an essential support to this project, and so it is with real admiration that I thank the Environment Agency, the LSC and SEEDA.

Sandra Harding-Deans
Chief Executive of AOSEC

Dr Anne Murdoch
Chair of Board of AOSEC and Principal & Chief Executive of Newbury College

Other Titles in the Series

This guide is one of a series of 5. The others in the series are on:

- ***Commissioning Sustainable Construction in Further Education Colleges***
- ***Conserving Energy in Further Education Colleges***
- ***Case study 1 - a post-occupancy evaluation of a recently-completed FE building***
- ***Case study 2 - a post-occupancy evaluation of a recently-completed Academy building***

The partnership would like to acknowledge the feedback received from King Sturge and GVA Grimley in preparing this report.

The images on the cover page are of Aylesbury College extracted from www.aylesbury.ac.uk.

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How to use the guide

The guide is designed to provide an overall strategy for water conservation through various stages of designing and using a building within colleges.

The guide is divided into three broad sections:

- The first section provides a general evaluation of where and how much water is used in further education colleges and the need for water conservation within the present context.

- The second section explores design considerations for reducing water use in buildings through efficient plumbing design and services and on-site water capturing and treatment technologies.

- The final section looks at building operation and maintenance and explains a methodology for a water audit and optimal water consumption during use. It is targeted at building managers.

It is a basic guide and should be used with the sources of further information provided.

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EXECUTIVE SUMMARY

This guide provides information on water conservation in colleges through design, construction, operation and maintenance. It explains the various principal end uses of water in FE colleges and provides key measures and strategies to reduce water consumption.

This guide is about:

- Water end use in FE Colleges – where and how much water is used.
- Water conservation – how can consumption be reduced effectively through design, appropriate technologies and water auditing.

This guide will help

- **Colleges (construction clients)** to invest in water conservation fittings and technologies such as rain water harvesting by understanding capital and associated benefits of each measure.

- **Design teams** to address the range of issues to enable efficient use of water within the building by minimising use and exploring appropriate strategies for reducing dependence on water from the mains by harvesting or grey water recycling etc.

- **Estate managers** to implement management strategies such as water auditing to assess and benchmark water use in the college and to understand ways of reducing consumption.

CONTENTS

1. INTRODUCTION

Why conserve water

Water is the most precious of all resources, to sustain it, is to preserve life. However, the careless attitude towards the misuse of fresh water linked with its growing scarcity caused by population growth and climate change, suggests that rational use of water and the adoption of conservation measures are urgently needed.

To sustain this valuable resource, it is imperative to first understand how and where water is used in college buildings and compare this consumption with benchmarks.
This would enable the sector to realize the water saving potential that exists and help in devising effective strategies to achieve it.

For years freshwater supplies have been assumed to be an inexhaustible resource, strongly depending on its regenerative capacity offered by the naturally occurring water cycle.
Our planet contains a finite quantity of water, where 97.50% of the supply can be found within the oceans in the form of saltwater and only 2.50% is fresh. Most of this freshwater is difficult to access, in the form of ice within the Polar Regions and mountains or groundwater. Only 0.01% of all water on Earth is useable by ecosystems and humans (Shiklomanov 1999).

There are also a number of human-induced factors which are affecting the quality and quantity of global freshwater resources.

- **Increase in demand due to population growth** leading to over exploitation of water sources.
- **Degeneration of water quality due to human activities** such as deforestation, urban growth, industrial and agricultural practices.
- **Change in rainfall patterns** due to global warming and climate change. (Shiklomanov and Georgiyevsky 2003)
  In UK, in recent years, lack of rainfall has resulted in groundwater and reservoir water levels becoming dangerously low in south-eastern England. Due to this, certain regions in UK faced hosepipe and sprinkler bans as means to reduce freshwater consumption to control supply.

Why consider water conservation in FE buildings?

- Environmental conservation: Reducing dependence on mains water supply can reduce the strain on an increasingly scarce resource.
- Future legislation: The government is currently reviewing its policy for setting targets for water consumption. It is only a matter of time before mandatory regulations are introduced.
- Social responsibility: Colleges have a role to play and can lead by example.
- Reduced water bills: Efficient use of water within FE buildings will lead to reduced water bills.

Hence, all new and existing college buildings should attempt to close the loop within the water cycle.

- Precipitation falling on sites should in theory re-charge aquifers and natural waterways.
- Water entering a college building should be used efficiently, in order not to diminish its source, and returned to the natural environment in a state that enhances aquatic habitat.
- If contamination occurs, the building should provide the necessary treatment to remove pollutants.

To achieve the above objectives, it is essential to understand where and how much water is used within the college buildings.

1.1 Understanding Water Consumption

Freshwater of potable standards is supplied to urban areas by Municipal authorities for consumption (DWI, 2005), and is mostly used for drinking and cooking, bathing, washing and cleaning, waste transportation and irrigation of landscaped areas.

Although there are considerable variations of water use within the non-domestic sector relating to building type, size and construction age, the typical non-domestic building consumes around two-thirds of water for urinal and toilet flushing.

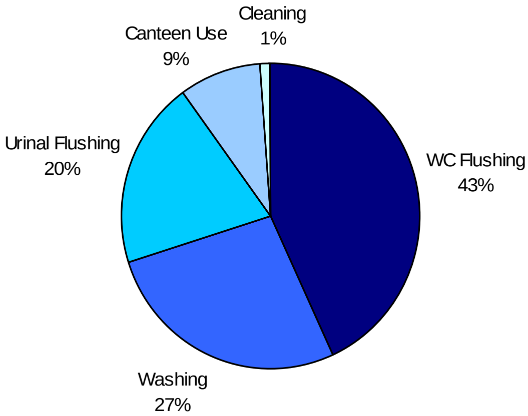


Figure 1. Typical non-residential water use. Source: (Environment Agency)

Overall, the average per capita water consumption in the UK is around 150 litres/person/day (OFWAT 2006), where a typical full-time employee (or student) consumes up to 40 litres/person/day within the non-domestic sector (Envirowise 2007).

It is important to benchmark water use before a new building is constructed such that strategies can be targeted to achieving the specified water use in the early design stages.

1.2 Benchmarking Water Consumption

Water consumption levels can be benchmarked and compared in three main categories: typical, best practice and excessive use. By making use of key performance indicators, such as water consumption per capita or water consumption per building area, it is possible to benchmark and compare FE buildings.

	Cubic meters per year	**Litres per day**
Typical use	4.0 m^3/person/annum	15.8 litres/person/day
	0.6 m^3/m^2/annum	2.4 litres/m^2/day
Best practice use	2.0 m^3/person/annum	7.9 litres/person/day
	0.4 m^3/m^2/annum	1.6 litres/m^2/day
Excessive use	7.0 m^3/person/annum	27.7 litres/person/day
	0.8 m^3/m^2/annum	3.2 litres/m^2/day

Table 1 **Water consumption benchmarks for non-domestic buildings.**
Source: (Wagget and Arotsky 2006)

The level of performance achieved by each building could be measured and compared to identify which building performs the best and why.
By doing so, it is possible to pin-point effective strategies adopted by the best-performing buildings. Buildings which present a consumption rate above average indicate that its performance could be improved by applying demand-side and supply-side water conservation measures.

2. DESIGN & CONSTRUCTION

It is integral to incorporate water conservation strategies in the initial design and construction stages of the project including efficient plumbing design, appropriate fixtures and controls.
Design stage is also the most suited for allocating space for employing rain water harvesting or grey water treatment measures and incorporating it into a larger landscaping strategy for the building site.

2.1 Water Conservation: Demand-side measures

Water consumption can be reduced significantly by adopting simple and cost-effective water saving measures such as installing water-efficient fittings, fixtures and appliances to achieve long-term reductions in water consumption.

2.1.1 **Efficient Plumbing Design**

Efficient plumbing design should be adopted in order to promote water conservation within FE college buildings.

- The location of water appliances as well as ‘wet zones’ (i.e. bathrooms toilets, kitchens, among others), should be thoughtfully placed near each other to prevent unnecessary pipe work and avoid additional transportation of freshwater to points of use.
- An effective hydraulic calculation promotes the ideal dimensioning of plumbing pipe work and features for a building and therefore avoids the superfluous use of extra water.
- All plumbing systems should be provided with periodic maintenance and always be free of leakage to ensure optimal performance.

2.1.2 **Fittings, Fixtures and Appliances**

Specifying low-use or water-less fittings and fixtures can effectively reduce the amount of freshwater consumed in a FE building. These include:

I. **Water meters**

Installing water meters provides a clear indication of the amount of water consumed as opposed to predicted mains water bills.

- Exact cost of water used can be transferred to specific buildings or departments making them accountable for their use.
- This can also help in targeting conservation strategies to influence the occupants to reduce consumption through daily actions.
- Water meters also make it easier to detect irregularities in consumption and can help identify leaks within buildings.

Figure 2. **Digital Water Meter**
Source: (www.stwater.co.uk)

II. **Flow Regulators**

The use of flow regulators within plumbing systems balances the pressure, dividing the available flow between outlets at a sufficient rate.

Therefore, if tap water is employed whilst shower water is on use, the flow and temperature shall remain stable. This leads to water and energy savings when users leave taps and showers running at full flow rate.

Figure 3. **Flow Regulator**
Source : (www.robertpearson.co.uk)

III. **Aerators**

Aerators maximize the effectiveness of taps or showerheads and also assist in maintaining a constant flow of water by mixing air into the water stream and distributing low flow water as spray.

- The use of aerators can reduce flow rates to as low as 2 lpm (litres per minute) for taps and 3.7 lpm within showerheads, hence, reducing the overall flow of mains water.

IV. **Water taps**

- Low flow taps can save up to half the volume of conventional taps.
- Automatic closure taps, can further reduce consumption by a possible 20% reduction compared to standard taps.

- Electronic taps may be able to promote 40% tap water savings compared to conventional taps, by automatically controlling water release via a infrared sensor.

Figure 4. **Sensor Taps**
Source : (www.ukhomeideas.co.uk)

V. **Showerheads**

Showers generally use one third of the water required for a bath, however, the frequency and time spent in the shower largely governs the actual use. Pumped or power showers can consume more water than a bath in less than 5 minutes.

- Low-flow rate showerheads with flow restrictors and aerators can help use less water than standard showers.
- Automatic or sensor shut-off nozzles can also be used to minimize wastage.

Figure 5. **Low-flow showerhead**
Source: (www.wbdg.org)

VI. **Low-flow toilets**

Standard toilets require 13.5 litres per flush. Since, the maximum use of water in non- domestic buildings is for urinal flushing, it is essential that efficient fixtures are used.

- Use 6 litres low-flush toilets instead of standard ones. This can provide an overall savings of 40 – 50% compared to the standard WC's.
- There are also ultra low-flush toilets available with improved bowl design to facilitate cleaning, which makes use of only 3 litres per flush.

- Dual flush valves on toilets can also be used, where a 4.5 litres flushing volume is used for solid waste and a smaller flush volume of 2.2 litres is applied for flushing liquid waste.

VII. **Conversion kits**

Existing gravity-tank toilets can be adapted into a dual-flush system through the installation of a flush-converting device within the water tank of most conventional toilets. This can result in water savings of almost 40% within non-domestic buildings.

Figure6. **Single to Dual flush conversion kit**
Source : (www.ecobeta.com)

VIII. **Dry toilets**

Waterless toilets use no water for flushing. Instead, they use naturally occurring biological treatment processes for breaking down waste and turning sewage into compost which can be used as soil fertilizers. The toilet consists of a well vented and drained collection chamber with an access hatch for annual compost removal. Roughly, 1m^3 of compost is produced per person on an annual basis, and if produced carefully should pose no risk to health.

IX. **Water-less urinals**

Water-less urinals are commonly used as public toilets within commercial, institutional and office buildings. They consist of a urine-trapping device which replaces the drain found in a traditional urinal and hence, require no water for flushing.

X. **Appliances**

All Appliances required such as dishwashers etc. in catering services should be water efficient. Most of these have a dual benefit of being energy efficient and saving water at the same time. Most appliances in the market today come with energy and water efficiency labels indicating their level of performance.

Most of the above measures can be easily retrofitted in existing buildings as well. There are various fittings which can be added on to existing systems and do not require complete replacement of all the parts. The cost varies depending on individual measures. An example of retrofitting water less urinals in Chichester College substantiates the associated cost and environmental benefits of water saving measures.

Case Study: Chichester College

The college retrofitted about 75 water less urinals into existing urinals on the entire site after a successful initial trial. It has led to savings in costs and water use while improving the environmental performance of the college.

- The trial dispelled myths about hygiene issues, instead, washrooms were found to be fragrant and welcoming.
- The retrofitting was efficiently managed with minimal disturbance.

Annual water use for flushed water systems in the college = 11,000m^3
Annual savings in costs for the above water charge = £13,500
Further savings for no flush control = £20-30/urinal amounting to £2000
Maintenance charges for the new units = £ 7000/year
Total savings = £15,500 – £7000 = 8,500/year

2.2 Water conservation: Supply-side measure

The following section explains supply side measures i.e. alternative water sources which can be tapped such as rainwater harvesting, grey water recycling and wastewater treatment through reedbeds. Although supply-side measures do not have a direct influence towards the reduction of water use, they promote water conservation by reducing dependence on mains water.

2.2.1 Rainwater Harvesting (RWH)

What is a rainwater harvesting system?
Rainwater harvesting systems collect rain from the ground or building roofs and, rather than allowing it to drain away, filter the runoff and store it for later use.

How does it help conserve water?

- Rainwater harvesting is a simple concept which promotes self-sufficiency by reducing dependence on mains fresh water supply.
- It conserves water by collecting and using rain water which would have otherwise drained away from the site.
- It also minimises local erosion or flooding caused by run-off.
- Rain water also has the additional advantage of being relatively pure, soft, oxygenated and free.

How is rain water harvested?
Rainwater harvesting systems consist of three basic components apart from other components such as filters, pumps, and controls.

I. **Catchment area** is the surface from which rain water is collected such as the ground or roof surfaces of the buildings.

- Ground catchment surfaces include paved areas surrounding a building like roads, car parks etc. Filtration and disinfection is generally required for rainwater harvested from these surfaces as it is likely to contain pollutants and contaminants.
- Roof catchment areas are the most commonly used surfaces because of less pollutants and contaminants in the collected water as compared to ground surfaces. It must be ensured that roofing materials are non-toxic surfaces avoiding paints, nails and certain metallic materials.
- Other forms of roofs such as green roofs can also be used as catchment surfaces for collecting rainwater, although they may absorb up to half of the final volume of rainwater.

II. **Delivery system** consists of any pipe network including gutters, downpipes etc. used to deliver the collected water from catchment areas.
   - It is crucial to clearly label the pipes and not to cross-connect rainwater with mains pipe work in order to avoid risk of consumption and mains contamination.

III. **Storage tank** is also called as the collection tank. It is the main tank which stores the collected rain water and provides water to various points of use.

The following diagram explains the key mechanism for a rain water harvesting system.

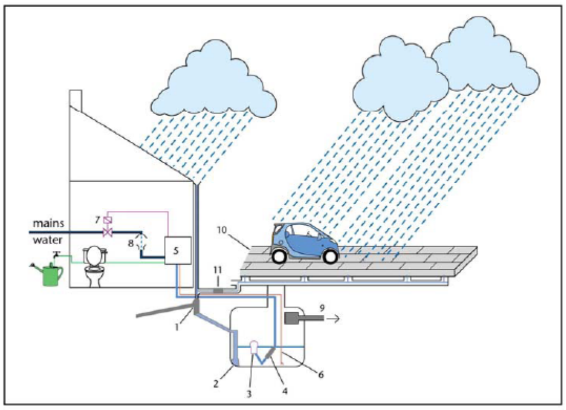


Figure 7. **Schematic of a Standard Rainwater Harvesting System**
Source: (Environment Agency)

What can the harvested rain water be used for?
Depending on the treatment of the harvested water, it can be put to various uses.

I. Untreated Rainwater Use
   Untreated rainwater has potential for bacterial contamination (Environment Agency 2003) and hence, should only be used in selected types of water demands where there is no risk of consumption, such as garden irrigation and other external uses such as floor washing or water decorations such as fountains.

II. Filtered rainwater use
   If rainwater is to be used internally, for toilet flushing or washing machines, the water should be filtered to remove debris, organic

materials, such as leaves and sticks, and possibly other suspended matters such as dust and earth. The filtered rainwater is then stored in a tank and can be directed to points of use.

III. Potable rainwater use
Government regulations require a high standard of water quality for consumption. For potable uses of rainwater, such as cooking and drinking, processes such as micro-filtration and disinfection are necessary. A fail-safe mechanism is also crucial which would automatically cut supply in case of any equipment failure or if the necessary water quality is not obtained.

Issues to consider while designing a rain water harvesting system

- Before specifying a RWH system, for a proposed building, it is crucial to evaluate the site's potential rainwater yield depending on the region's rainfall and size of the collection or catchment area.
- Cross reference this supply with the estimated water end-use demand. It is also important to balance rainwater supply and consumption demand so that end-use consumption rates never exceed supply.
- Determine exactly where rainwater can be used and the necessary storage volume required.

2.2.2 Grey Water Recycling (GWR)

What is grey water recycling?
Grey water is water from washing sources such as baths, showers, wash basins, kitchen sink, washing machines and dish washers. Grey water contains a range of contaminants such as organic matter, grease, soaps and detergents, hair, among any other impurities which might be poured down the drain.

Grey water recycling systems reuse this water by collecting it in a storage tank and pumping it to be used in generally for non-potable purposes such as in toilet flushing. Water is contained within a closed system and is mostly treated to reduce the risk of disease and contamination.

How does it help conserve water?
Recycling grey water reduces the amount of freshwater required for without limiting water consumption, and hence, helps in conserving water. It also decreases the volume of water discharged as sewage.

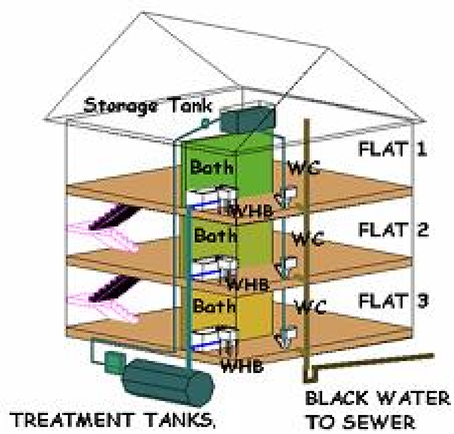
How is grey water recycled?
Grey water recycling systems largely depend upon the volume of grey water created and the amount of treated water needed for supply. Based on the requirements, small to large community based systems can be used.

There are three main components in any GWR system, apart from components such as pumps and controls.

I. **Collection and distribution pipe** work consists of the closed pipe network for collecting grey water and supplying it to points of use.
Grey water pipe work should be clearly labelled and distinguished from mains water pipes so as to avoid cross-connection and therefore mains contamination (WRAS 1999).

II. **Treatment** varies from basic filtration, aerobic and anaerobic treatments and disinfection processes.

III. **Storage**
Grey water tanks are usually small in size as the storage time of the treated water is limited. Automatic devices remove the water within the tank, to foul sewer, if it is not used within a maximum of three days.



The figure shows a system for multi-storey buildings where a single large-scale grey water recycling system is used to provide the necessary treatment for the grey water generated. After disinfection, the treated water is pumped to a central distribution tank, which supplies recycled grey water to points of use via gravity.

Figure 8. **Multi-storey GWR system.**
Source:(www.esru.strath.ac.uk)
)

What is the recycled water used for?
The use of grey water depends on the resultant water quality based on the source of the grey water and the filtration process carried out.

I. Untreated grey water reuse
Untreated grey water should not be stored for over a day, due to pathogenic bacterial growth and should be used immediately after it is produced.
- Untreated grey water is generally used for watering the garden.
- It must never be applied over plants that might be consumed raw.
- Grey water from kitchen sink and dish washers should be avoided for use without treatment because they contain high levels of grease, fats, sodium, bleach and borax. Grey water from washing machines can be used if softeners are avoided.

II. Treated grey water reuse
To be considered safe, grey water systems should be able to cope with the worst conceivable contamination from known sources, and therefore should include some form of disinfection after it has been treated. Disinfection prevents biological activity to allow the treated water to be stored for a limited period of 3 days.
- Treated grey water can be used for toilet flushing.
  Recent commercially available compact grey water systems claim to have eliminated the problems of unpleasant odours and bowl staining generally associated with reusing water by providing necessary treatment and disinfection.
- It can also be used in washing machines, and for irrigation purposes.

2.2.3 Waste Water Recycling: Reed beds

What is waste water recycling?

Waste water also called as black water consists of sewage and water from toilets. A common method of recycling waste water is through reedbeds. Reedbeds are artificially created wetlands with reed plants which provide the ideal conditions for the development of micro-organisms capable of promoting aerobic treatment for sewage.

This naturally-occurring treatment process is capable of recycling wastewater to the form of purified water. As it returns all solid matter to the soil, organic sludge is consumed by micro-organisms, plants, and aquatic wildlife as a food source. The reed plants used need periodic harvesting to encourage new growth, and can be used for composting.

How does it help conserve water?

Waste water is purified from reed beds and can be put to various uses. It thus, conserves water by recycling waste.

Reedbeds are environmentally friendly, contribute to the conservation of fresh water and promote natural habitat for wildlife. There are even examples of reedbeds used as garden or aquatic features in building sites.

How is waste water recycled?

Reedbeds are low-cost and low-maintenance systems, often operating without the need of mechanical or electrical equipment, as opposed to conventional treatment process. They however, require a certain amount area for the treatment process and therefore, reedbeds find application mostly within spacious building sites.

The type of reedbed largely depends upon the topographical terrain available on site and the potential flow of wastewater and is classified as horizontal, vertical or a combination of both.

Ponds, lakes and other aquatic wetlands are able to provide treatment to medium and strongly contaminated wastewaters, although, these require a large footprint for treatment.

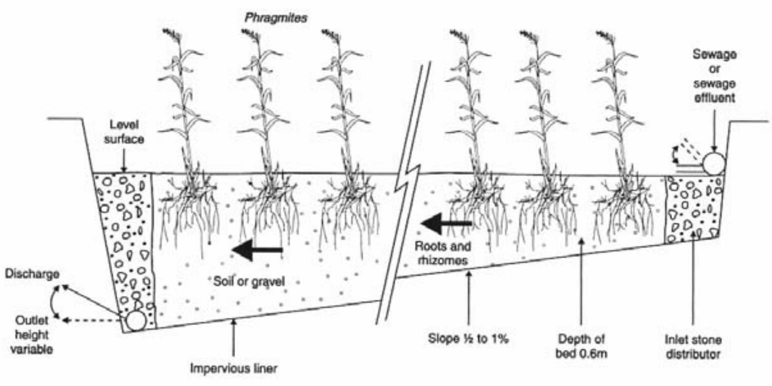


Fig. 9 **Typical cross-section of a Horizontal Flow Reedbed.**
Source: (Environment Agency)

What is recycled waste water used for?
According to the level of treatment, water from reedbeds can be used to various uses.

I. Treated Use
Biologically treated wastewater by reedbeds can be easily used for garden irrigation and toilet flushing.

II. Potable Use
The treated wastewater from reedbeds must undergo a complex disinfection process in order to attain standards for potable use. The disinfection process often includes the use of membrane filters, UV and chlorine disinfection, which are usually complex and costly to maintain.

2.3 Sustainable Urban Drainage Systems (SUDS)

Site planning and design should consider the impact of new construction on the local water system, as supply and demand side measures only help in conserving water with respect to the requirements of the buildings.
Incorporation of Sustainable Urban Drainage Systems helps in addressing the wider environmental impact of water run- off from new or existing buildings.

What are sustainable urban drainage systems?
Sustainable urban drainage systems is a collective term referring to a range of measures used for managing urban run off from paved building areas in a sustainable manner.

Traditional drainage systems are based on underground pipe networks which remove water from building sites. In cases of increased rainfall, huge quantities of water are directed to water sources causing flash floods. This also prevents any ground water recharge. Also, the quick run-off does not allow for any retention of pollutants or silt which are also carried to the catchment areas such as rivers, compromising their water quality. SUDS prevent this by providing sustainable solutions to manage run- off locally.

How do they help conserve water?
- Suds reduce the possibility of flash flooding by detaining run- off and releasing water from urban areas slowly into the water sources. This also helps in improving the resultant water quality.
- Large SUDS such as wetlands also provide a natural habitat for wildlife and can have recreation potential as well.

How do SUDS work?

SUDS employ a range of techniques to effectively manage urban run – off at source (Environment Agency).

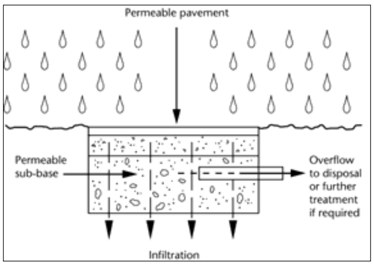


Figure 10. **Permeable Paving**
Source: Environment Agency

1. Control of run- off at source

a. Permeable paving: run-off is allowed to percolate through a porous paving surface to reduce the need for surface water drains.
b. Green roofs: are used to reduce the peak flow of water as they absorb a large percentage of water falling on them.

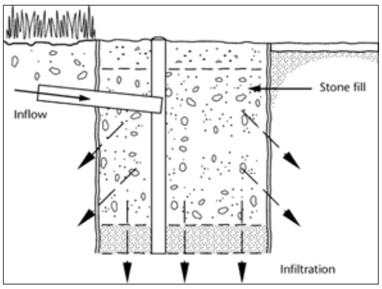


Figure 11. **Infiltration Trench**
Source: Environment Agency

2. Infiltration trenches

a. Infiltration trench is an excavated trench filled with stone which acts as an underground reservoir. It allows gradual infiltration of water into the ground and can be combined with a filtration technique to remove excessive solids from the water.

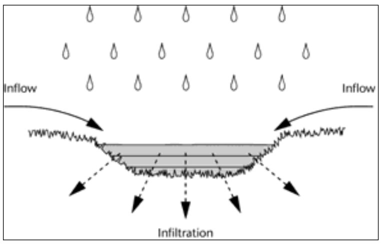


Figure 12. **Basin**
Source: Environment Agency

3. Swales and Basins

a. Swales are linear grassed depressions to receive run off and slowly move it to the discharge point. They may be used to replace conventional roadside kerbs.
b. Basins are dry outside of storm periods and are meant to hold water for a few hours such that solids such as pollutants and silt can settle down.

4. Ponds and Wetlands

a. Integrated wetlands or ponds can be developed as landscaped features within building sites to direct the run-off locally.

Case study: Aylesbury College

Ayelsbury College has incorporated a detailed sustainable urban drainage system, particularly for controlling storm water at source, in conjunction with the Environment Agency.

The site previously discharged water to the adjacent California Brook at an unrestricted rate and the design sought to reduce this impact.

- The large area of car park incorporates a dry shallow flood basin to retain water during heavy rainfall.
- Additionally, the car park is allowed to flood to about 150mm during severe rainfall.
- Car parking bays also incorporate permeable paving.
- Run-off from external paths and footpaths is diverted into adjacent infiltration swales around 100-200mm deep.

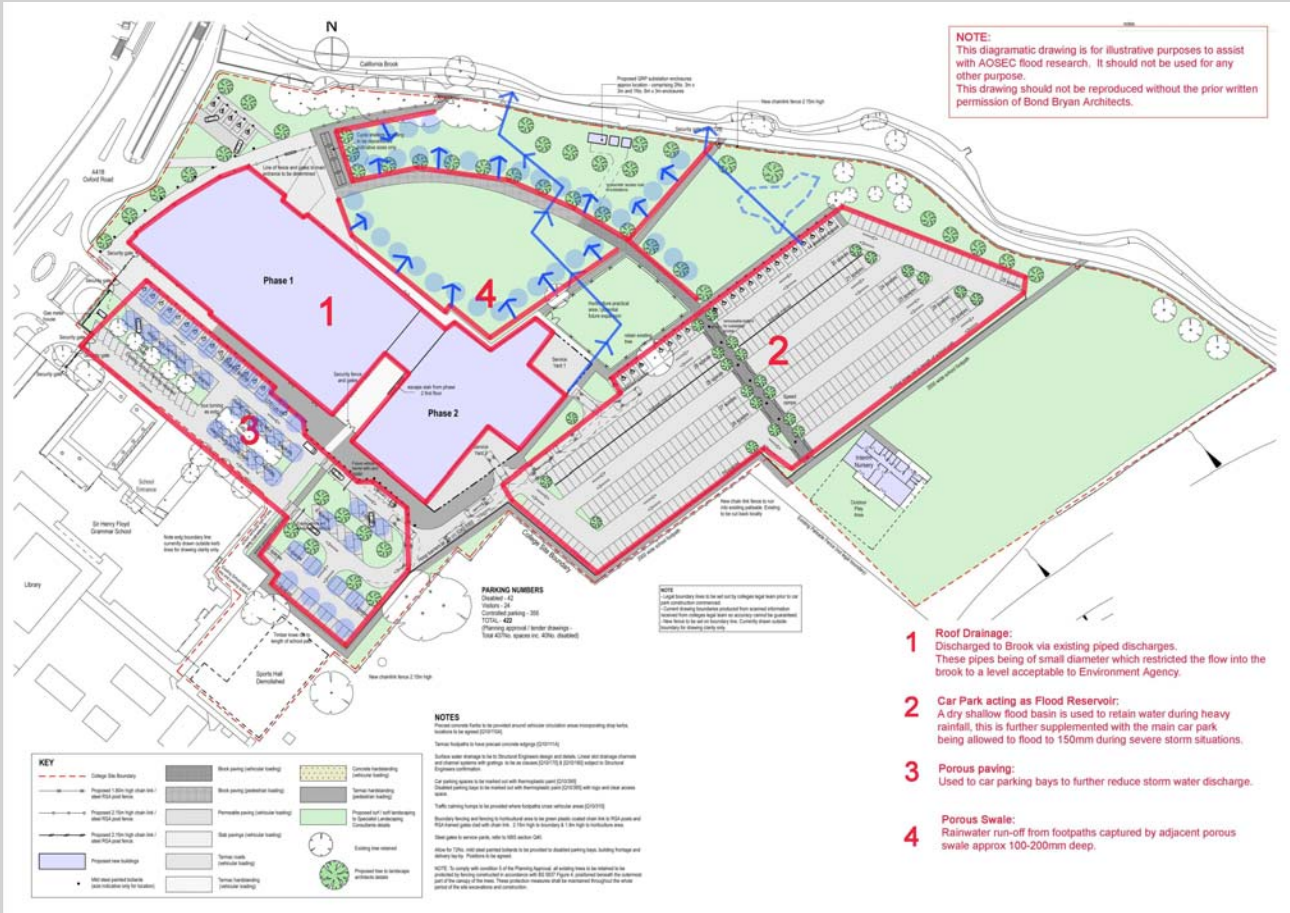


Fig. 13 **Plan showing sustainable Urban Drainage Strategy in Aylesbury College**
Source : Bond Bryan Architects

2.4 Cost Benefit Analysis

This section provides indicative costs of some of the water conservation measures mentioned earlier.

Measure	Estimated cost	Additional information
Water saving fixtures & fittings		Additional cost above a standard fitting in a new build. (multi buy options could reduce costs)
6/4 liters flush WC	£ 80	
Aerated tap	£50	
Sub – metering	£ 231[1]	
Grey water recycling	Site-specific basis	
Rain water Harvesting	£6263-32,073[1]	
Sustainable urban drainage system (SUDS)	Site-specific basis	

[1] Costs are representative and have been extracted from estimates by BRE for the Building Regulations compliant 'base case' naturally ventilated (lower range) and air-conditioned office (higher range) published in 'Putting a price to sustainability'

Table 2**. Typical costs of measures to increase water efficiency in buildings**

✓ **Reduce** water consumption through efficient fixtures and plumbing design.

- Efficient plumbing design.
- Sub metering of water for separate buildings.
- Efficient fixtures such as low flow taps, shower heads and toilets and water less urinals.
- Efficient appliances for catering and other uses with specified water efficiency labels.

✓ **Recycle** water using **Grey Water** systems.

✓ **Reuse** water through **Rain Water Harvesting** and filtering technologies such as **Reedbeds**.

✓ Landscaping and site layout should avoid run-off by creation of **Sustainable Urban Drainage Systems**.

3. OPERATION & MAINTENANCE

This section describes the mechanisms for reducing water use once the building is operational. Efficient fixtures and fittings reduce the amount of flow of water; however, it is equally important that water use is periodically assessed or audited to detect wastage caused either by the users or due to leakage. This will also help the building management in devising appropriate strategies for water conservation.

Most of UK's existing FE colleges do not have actual metered data to know exactly how much water is being consumed by them. Such organizations, hence, end up spending more on mains water and wastewater charges than what is really needed. Such existing and even new buildings of the FE estate can reduce their water consumption simply and inexpensively by auditing water use and identifying appropriate water-saving measures.

3.1 Water Audit

The first step to promote water savings during operation and maintenance stages of FE buildings is to carry out a water audit to fully understand how much water is being consumed and where such consumption is taking place.
This will provide information if the building consumption is similar to that calculated while incorporating design measures and give important clues for further water conservation strategies.

What is a water audit?
A water audit includes measurement of the quantity and quality of water input within a building or site, assessing the use it is put to and measuring the water output as well (Sturman, Goen et al. 2004).

Such an analysis helps to plan appropriate actions for water conservation, efficiency and management.

- Water audits can quantify water end-use patterns of different points of use within a building.
- They are capable of assessing the overall plumbing performance and pin-pointing inefficiencies within the network such as high consumption area and leakage.
- Water audits provide a reliable assessment of water consumption within a building for a proper analysis.

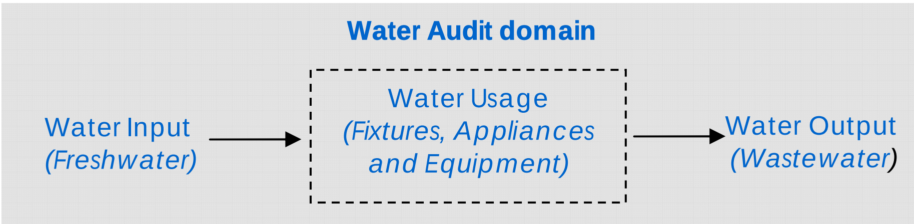


Fig. 14 **Principles of water audit** Source: (Sturman, Goen et al. 2004)

3.1.1 Assessing Water Consumption

The first step in a water audit is to understand the annual consumption of the FE College by measuring the water that flows into the building and that which flows out as sewage and run off.

- Review the building's past water and sewage bills to understand its annual consumption, if the building has metered or sub metered supply of water.

- In case of existing buildings or buildings which do not contain metered readings, bills are based on calculated estimations which do not represent a precise pattern of consumption. It is essential to estimate demand in such cases based on the number of users in the building.

  Estimating Demand
  The annual water demand may be estimated through the following equation:

$$\textbf{Annual Demand } (m^3) = \frac{\text{Av. Consumption per Capita} \times \text{No. of people} \times \text{No. of working days}}{1000}$$

3.1.2 Pre- Audit

Before a water audit is carried out, it is essential to decide its scope and time range. Ideally, audits are scheduled on a time-line ranging within a daily, weekly, monthly or even annual basis depending on how detailed the audit is.
In order to establish the audit scope, it is crucial to identify and quantify all water-consuming appliances and fixtures of the building (or buildings) at hand. This can be done through the following ways.

- If available, make use of plumbing design layout, pipe work plans and sections to aid in the identification of every water-consuming product within the building. If such blueprints are not available, it is advisable to draw a sketch of all appliance and fixture layout.

- A water flow diagram can be used as a tool to fully understand the process of water flow through the building's plumbing system (Sturman et al.).
  Such a diagram is extremely useful because the flow of each appliance, fixture and equipment can be individually measured and consumption balanced out. Figure 2.3 provides a visual example of what one FE building ground floor water flow diagram might look like.

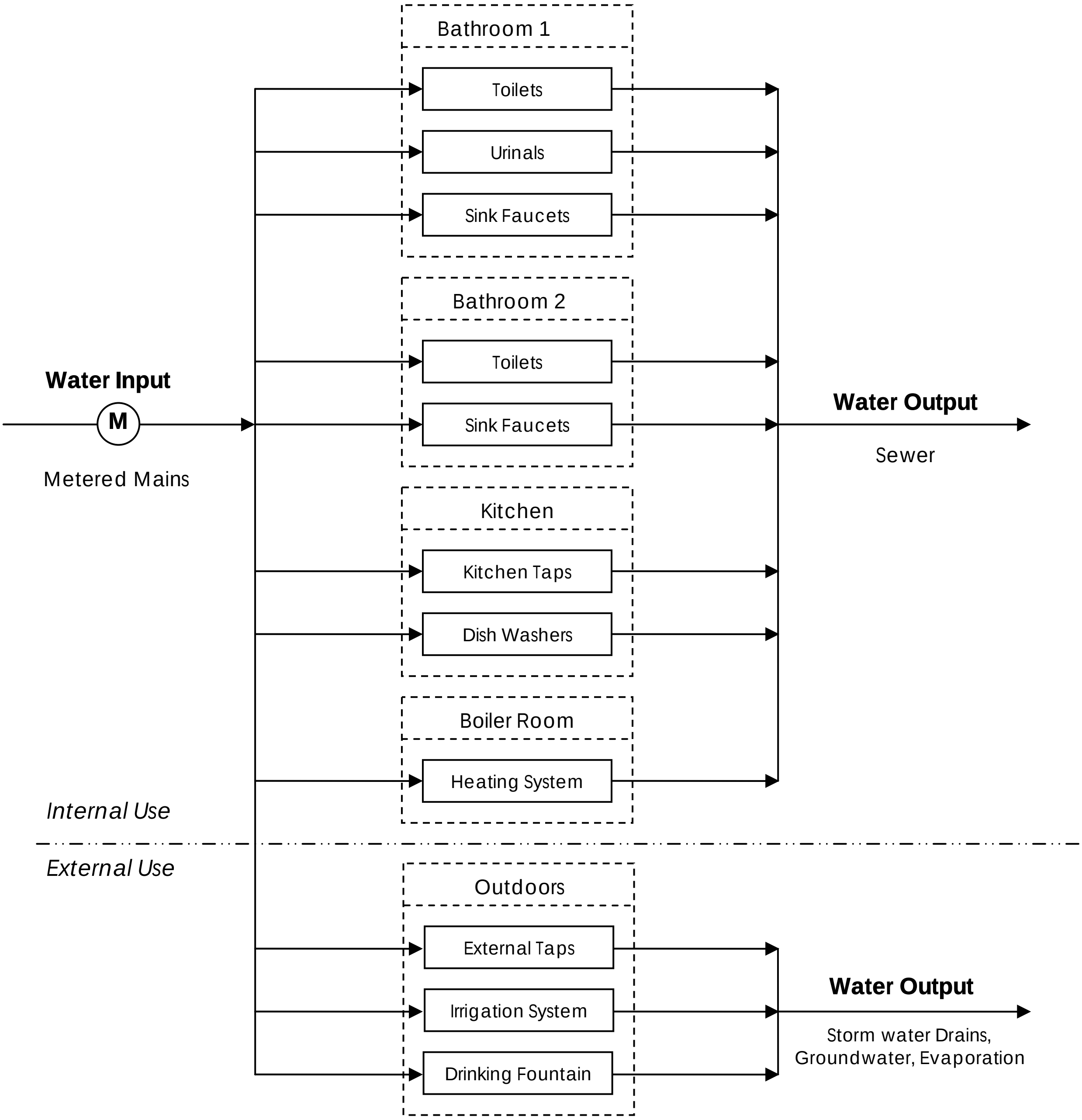


Fig. 15 **Example of a water flow diagram for the ground floor of a FE building**
Source: (Adapted from Sturman et al., 2004)

- Flow-rate tabulations can also be prepared for a complete inventory for all water-consuming appliances, fixtures and equipment within buildings and classifying their flow-rates.

Bathroom 1		
Number	**Appliance/Fixture/Equipment**	**Average flow-rate**
4	Flush Valve Toilets	6 L/Flush
3	Flush Valve Urinals	3 L/Flush
6	Standard Sink Faucets	10 L/min (lpm)

Table 3. **Example of flow-rate tabulation for a bathroom**

- Also check for leakage within the building's plumbing pipe work, fittings, fixtures and appliances. This can be done through a visual inspection to detect dripping faucets or other leaking connections. Toilets can be tested for leakage by placing dye tablets within the toilet tanks; if dye appears at the basin, the toilet presents leakage. Communication with the facilities manager and related staff might be helpful to identify leaks throughout the building.

3.1.3 Conducting the water audit

A water audit can be carried out with the help of one or more of the following techniques depending upon the audit scope and specific requirements.

1. Metering

It is possible to monitor hourly, daily, weekly and monthly water usage within buildings which contain water meters. Although mains meters cannot identify end-use patterns, with the placement of sub-meters within a building, it is possible to measure individual uses within a building.

2. Data-logging

Data-loggers tend to be non-intrusive electronic devices which can monitor individual water flow patterns including detailed figures of time and place. Though, a highly reliable technique, it is generally costly.

3. Survey

Surveys can be conducted through the use of questionnaires distributed to staff and students. Although surveys cannot be considered as a precise method of measuring water consumption (i.e. How often do you use the WC?), they are a powerful tool in understanding attitude and behaviour related to water consumption (i.e. Did the water-saving campaign change your attitude towards water consumption?).
A separate set of questionnaires can be directed to those responsible for unit operations such as the facility manager or other related staff to understand operational schedules and attitudes.

4. Diary-tracking (Log-sheets)

Data collection via diary-tracking involves the cooperation of occupiers willing to record their water-usage through log-sheets placed near points of use. This type of data collection is most commonly related towards frequency and duration of use to be applied to flow-rate tabulations in order to estimate water consumption. This technique is more reliable than a survey (which relies upon people's ability to recall) and can also influence behaviour by raising awareness.

3.1.4 Audit Closure

Once data is collected and analysed, the water balance of input flow rates into the building is compared with the water output flow rates discharged, within a predetermined tolerance rate or error margin.
Such balance is extremely helpful to describe water usage and flow patterns. It also allows the identification of potential water overuse or abuse, and is able to detect hidden leakage within the plumbing.

The baseline water consumption data can then be compared to benchmarks for FE buildings to predict potential water savings and offer a cost-benefit analysis for each conservation measure proposed.

3.2 Role of Building Managers

The building managers play a pivotal role in conserving water and ensuring water efficiency standards are adhered to.
Regular water auditing to measure consumption and reporting and dissemination of such results to create awareness amongst users are essential for any effective water management strategy.

1. **Efficient management systems during operation and maintenance**
   a. Periodic water audits to ensure water efficiency standards are met.
   b. Reporting results from water audits to publicize savings in water quantities and cost achieved. This not only helps to increase awareness but also substantiates the need for conducting regular audits.

2. **Dissemination of information amongst staff and students**
   a. Educating occupiers by promoting public awareness of issues related to water resources.
   b. Water-saving campaigns can help to convince users to reduce water consumption through simple changes in behaviour.
   c. Informative posters or stickers placed near points of water use, can provide a constant reminder to users for modifying wasteful attitudes into reductive behaviour.

ACTION STEPS – Operation and Maintenance

- ✓ Assess resources for carrying out a **water audit**.
- ✓ Assess the water quantity that comes in and goes out of the building in the form of **past meter bills for water and sewage**.
- ✓ Evaluate the **water use from all fixtures**, fittings and appliances with the help of water flow diagrams and flow rate tabulations.
- ✓ **Balance this water use** with figures from past meter bills for water and sewage to see if the water use is accounted for.
- ✓ Don't forget to **allow for run-off** from irrigation uses, evaporative losses and **discount for any reuse or recycling** scheme incorporated into design such as grey water recycling or rain water harvesting.
- ✓ If the **balanced figure accounts for 80% of the use** when compared with past bills, the audit has successfully traced use of water within the buildings.
- ✓ If not so, then there might be **wastage of water** either by users or due to unknown leakages, which need to be rectified.
- ✓ **Compare this figure with benchmarks** for good practice use to calculate the saving potential of the building.
- ✓ **Devise strategies** to efficiently manage water in areas where excessive or wasteful use is detected.
- ✓ **Influence user behavior** by creating awareness and reporting results from the auditing process.

4. FURTHER INFORMATION

Organizations

1. **Environment agency** is the leading public body for protecting and improving the environment in England and Wales. http://www.environment-agency.gov.uk

2. **Envirowise** is a government programme that offers free and independent advice to UK businesses to reduce waste at source and increase profits**.** http://www.envirowise.gov.uk/water

3. **Defra** – the department for environment, food and rural affairs promotes sustainable development in government policies. http://www.defra.gov.uk/environment/water

4. **Ofwat** is the economic regulator of water and sewerage industry in England and Wales. http://www.ofwat.gov.uk

5. **ECA** - is a government scheme for Enhanced Capital Allowances on technologies promoting sustainable water use. http://www.eca-water.gov.uk

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