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# Greywater Recycling & Rainwater Harvesting Feasibility Study Sustainable Eastside

Faber Maunsell

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**Sustainable Eastside is a project supported by:**



# GREYWATER RECYCLING AND RAINWATER HARVESTING AT BIRMINGHAM EASTSIDE

Groundwork Birmingham

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GROUNDWORK BIRMINGHAM

GREYWATER RECYCLING AND RAINWATER HARVESTING AT  
BIRMINGHAM EASTSIDE

Prepared by: .....  
Rachel Waggett

Approved by: .....  
Catherine Pinney

Job No: 37261NAE  
Reference:  
Date created: 26th Feb 2004

Telephone: 0161 927 8200  
Fax: 0161 927 8499  
Website: <http://www.fabermaunsell.com>

Lynnfield House  
Church Street  
Altrincham  
Cheshire WA14 4DZ

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## INTRODUCTION



# 1. Introduction

## 1.1. Introduction to the feasibility study

FaberMaunsell has been commissioned by Groundwork Birmingham on behalf of Birmingham Eastside to carry out a feasibility study to consider potential implementation of greywater recycling and rainwater harvesting on Birmingham Eastside. The final report will be a useful guide for future designers and developers on the site.

The issues surrounding the use of greywater and rainwater are complex and considerable. It is not the intention of this document to explore all of these issues in great detail, but to give the reader a general understanding of the use of this technology and its potential application at Birmingham Eastside. There are several publications that provide more information, and these are listed in Appendix C: Further Information Sources. However an excellent overview can be obtained from two documents published by CIRIA that are recommended for anyone wishing to understand the subject more fully;

- CIRIA. 2001. Rainwater and greywater use in buildings: decision making for water conservation.
- CIRIA. 2001. Rainwater and greywater use in buildings: Best practice guidance.

This final report provides an overview of the potential for use of greywater and rainwater systems on the Birmingham Eastside development, and a brief discussion of some of the associated issues surrounding the use of such systems. Section 2 (Introduction to water reuse technologies), section 3 (Regulatory issues) and section 6 (Key design issues) will be of particular use to designers who might be considering such systems.

## 1.2. Introduction to Birmingham Eastside

The planned development of Eastside is part of the larger regeneration of Birmingham City Centre that has been ongoing over the last decade. The Eastside development area includes Digbeth, the Aston Triangle and the City Centre core retail area. Digbeth has a predominately urban and industrial character and is dominated by elevated roads and railway lines. The area is also bisected by the Digbeth Branch and Grand Union canals as well as the River Rea. To the north of the area is Aston University and Aston Science Park as well as Millennium Point, a regional landmark project to celebrate the new Millennium. A mixture of uses is being encouraged blending the new and old based on three guiding principles of learning, heritage and technology. There are plans for a new City Park, for a 'Learning quarter' and for the development of the canal and river waterfronts. Residential development is to be encouraged to promote life and activity outside of normal working hours, the majority of which will be for private sector or for educational/student needs.

Existing development on the site is primarily existing warehousing and light industrial units, with some residential and newer commercial buildings. Many of the warehouse and industrial buildings date from the last century, located at Eastside to make use of the canal network for freight transport and the river for power.

## 1.3. Introduction to Greywater and Rainwater recycling

It is useful to define what is meant by the terms 'greywater' and 'rainwater' for the purposes of this feasibility study. There is often confusion regarding the use of these terms which are often used interchangeably, and this can lead to considerable difficulty in communication of requirements.

For the purposes of this study, it is suggested that the most commonly accepted terms be used, as summarised below:

- **Greywater** Once used waste water, including waste water from bathing (baths, showers and hand basins) and 'clean' industrial or process purposes. For the purposes of this study, kitchen waste water is considered to be 'blackwater' as defined below, since this waste water often contains high levels of grease or food particles.
- **Blackwater** Significantly contaminated waste water, including that containing sewage, grease or oils, or chemicals from industrial processes that might be deleterious to health.
- **Rainwater** Surface water from roofs or hard surfaces caused by precipitation.
- All three types of waste water can be used in water recycling systems, however the level of treatment and the type of system required will vary depending on the type of water to be treated for reuse, and the end use to which it will be put.

Reused water is suitable for a number of different uses, which can be categorised as follows.

- **Non-contact use** such as irrigation through sub surface systems, flushing of tanks, or non-clean industrial process uses
- **Low contact use** such as use in WCs, first rinse in washing machines, or where there will be little or no contact with the water.

- Contact use such as use in bathing water, baths, showers and washing machines. This use will involve contact with skin and may result in accidental swallowing of water, therefore higher standards of treatment.
- Drinking water used for all purposes including kitchen and hand basins, where the water will be swallowed.
- Ultra-clean use such as use in electronic processes where the water must be ultra clean and purified before use.

In recent years there has been much discussion about the use of the term 'greywater' as it is an unattractive term and may discourage potential users to consider the technology. Various alternatives have been suggested, including 'greenwater', however the original term has been used for so long that it will be difficult to alter its use. This report therefore uses the term 'greywater'.

#### 1.4. Rainwater technologies

Rainwater storage has provided a source of water for communities around the world for millennia. In past centuries, river water (and often ground water) was contaminated by upstream use of the river for washing and sewage disposal, leading to outbreaks of cholera and dysentery in the UK as late as the 19th century. Rainwater storage was seen to offer a cleaner and less risky source of water, although the reasons for the diseases were not linked to contaminated water until relatively recently. Perhaps because of this distant memory, rainwater is still perceived by the majority of people to be a clean, fresh source of water, and therefore it is less subject to objection than greywater systems.

Rainwater is suitable for use without treatment (disinfection) although this does depend on the end use for which it will be used, and the method of storage.

There are examples in the UK of homes that use rainwater for all purposes including drinking. However these are few, and the majority of rainwater systems can be divided into three types:

- Irrigation systems
- Systems supplying WCs and washing machines
- Process systems

There are also different types of storage system, including sub-surface and roof storage, and storage in balancing ponds, but these will not be discussed at any detail at this stage, although they will be discussed further in the final report if their use appears viable on the Eastside site.

## WATER REUSE TECHNOLOGIES



## 2. Water reuse technologies

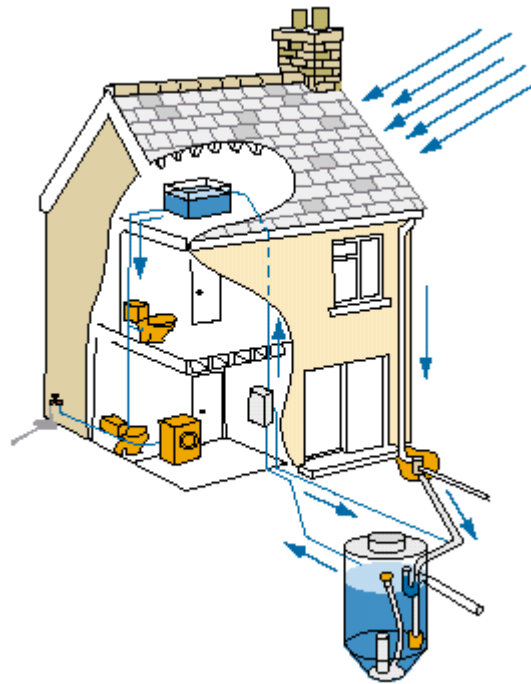
### 2.1. Irrigation systems

Irrigation systems at the domestic level are familiar to all, being a simple water butt with a downpipe connector to collect surface water running from the roof of the property. The water can be removed either by connecting a hose to the butt, or by using a watering can. These simple systems require little maintenance and are very useful for irrigation or for washing cars and other such uses. They are limited by their relatively small storage volume which means that there is rarely sufficient water for use throughout the whole dry summer period.

At a larger scale, irrigation systems can be connected to larger stored water tanks, which are often located underground as they are large, cumbersome and heavy vessels. Such irrigation systems are usually 'sub-surface' in that water is delivered below the ground directly to the plant roots, enabling a smaller volume of water to be used, and reducing the risk of members of the public coming into contact with the water.

### 2.2. WC and washing machine systems

These systems are more sophisticated as they require dual plumbing to be installed in the building, supplying the WC and washing machine, whilst other water uses are supplied by the standard mains water. In order to provide sufficient storage of rainwater to make the system viable, a large storage tank is generally installed. Storage at high level is possible, but with the majority of systems available, an underground storage tank is used, which feeds a small header tank at high level. The diagram below shows this type of system applied to a house.



*courtesy: Environment Agency*

The components of this simple system are:

- A filter which excludes leaves and other debris from the roof
- A storage tank
- A submersible pump which pumps water to
- A header tank located at high level
- A secondary water system that is clearly labelled as using non-potable water

The header tank can be automatically topped up with mains water should be rainwater fall short of supply. There are many examples of this type of system working well in both domestic and commercial properties.

More sophisticated systems are available which exclude the 'first flush' of rainfall after a dry period, when the roof is likely to be dusty and contaminated with bird droppings etc. This excludes the water that is most likely to be contaminated and reduces the risk of bacterial growth in the tank. These systems are more commonly used in areas of the world where rainfall is more sporadic, such as Japan and China.

### 2.3. Process systems

The use of rainwater and the level of treatment depends on the process that it will be used for. Rainwater has been collected in parts of Scotland for use in distilleries, and has also been used for vehicle washing in depots, for example.

At this stage it is difficult to be precise about the type of process that would be appropriate on this site, as not enough is known about the typical processes that are likely to be undertaken.

It is certain, however, that the office and industrial developments on the site will use some level of air conditioning. Water cooled air conditioning systems are energy efficient and well established, however there are few examples of the use of rainwater for their water source. Current literature would indicate that whilst rainwater is more 'soft' and therefore will reduce the level of scaling on essential systems such as heat exchangers, this very property can render it slightly corrosive to copper pipework. This would have to be taken into account in system design and will be investigated further.

### 2.4. Greywater systems

As defined earlier in this report, greywater is water collected from baths, showers and basins. It can also include some process water that is slightly contaminated, but not with substances that might be deleterious to health. For the purposes of this report, water that has been used in kitchens and washing machines has not been considered 'greywater' as these sources generally require greater levels of treatment than typical greywater.

The majority of systems in the UK at present either available to buy or installed, are designed to be used in domestic properties, however it is of course possible to use greywater in other buildings. The only potential drawback will be one of viability – typical commercial buildings produce little greywater in general operation.

The majority of greywater systems found in the literature examined so far fall into the following types, similar to the rainwater systems above.

- Irrigation systems
- WC systems and 'first rinse' washing machine water
- Process systems

### 2.5. Irrigation systems

The consensus of information from the literature reviewed is that irrigation is possible using greywater without treatment other than basic filtration. There are a number of caveats that accompany this use, for example, the irrigation should certainly be sub-surface to exclude the possibility of contact with people, plus it should not create aerosols through spraying. Also, the irrigation should not be of crops that could be eaten uncooked. This would exclude the use of irrigation of allotments, for example.

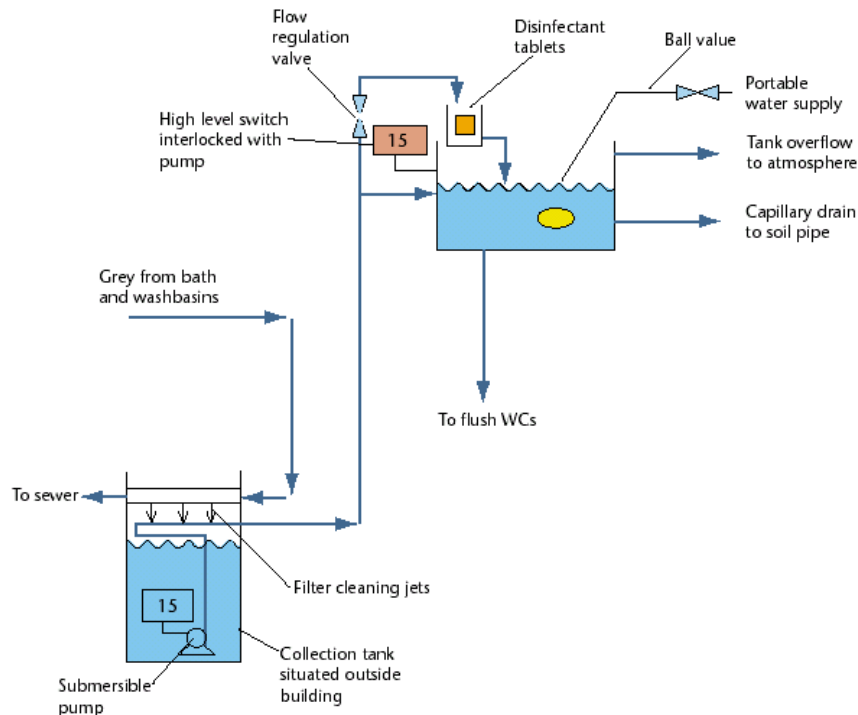
Basic filtration is necessary to exclude hair, soap and other debris before use that would clog up the system, however the evidence available would suggest that no other constraints occur. This technology is particularly well used in areas of the USA such as California, where irrigation of lawns is not permitted in the summer months due to droughts.

### 2.6. WC and 'first rinse' water systems

Greywater recycling for use in WCs has been applied in the UK almost exclusively on the scale of a single domestic property. This is partly because of the nature of the majority of properties (low rise houses rather than apartments with communal servicing) and partly because commercial properties lend themselves less well to greywater recycling.

The systems are similar to those for rainwater reuse, however they have a few important differences. The tank size is generally smaller, since greywater is produced daily from typical bathing patterns, and therefore will not need to be stored for a considerable period. The other important difference is that the majority of systems include some element of disinfectant, such as hypochlorite tablets, which ensure that any bacteria present in the water is eliminated.

An example of one of the best established system technologies is shown in the diagram overleaf:



Courtesy: Well Butt system, Water Dynamics

The components of these systems include:

- A connection from bath and basin to the greywater system, appropriately labelled (details of labelling will be contained in the final report)
- A filter system of varying complexity
- A relatively small volume collection tank, situated either outside the building or within it, depending on the system)
- A submersible pump that will pump the water to
- A disinfectant dosing chamber through which the water will flow into
- A small header tank that can be topped up by mains water
- Connection from this tank to WCs.

'First rinse' washing machine water does not need to be as clean as that used in later rinsing stages, and therefore it is possible to use greywater for this purpose. The majority of domestic machines do not have the ability to utilise different water sources and so this would be more appropriate for commercial laundry machines. Some machines can store and reuse water used for the last rinse of the wash, as the first rinse of the next and directly reuse water in this way.

## 2.7. Process systems

Greywater or once used water has been used with frequency in industrial operations and there are many examples around the UK.

## 2.8. Combined greywater and rainwater systems

It is possible to combine greywater and rainwater in the same system. This has both advantages and disadvantages. The advantage is that the volume of water collected will be greater and will be more consistent in volume than a rainwater system, for example. The disadvantage is that there will be a greater storage volume than a simple greywater system, with the same need for disinfectant (since the water must be treated according to the lowest quality).

## 2.9. Communal and shared systems

The majority of the systems contained within the literature reviewed are systems intended to be used on a single building or within a single family dwelling. However it is possible to share reused water for WC flushing, irrigation or process water. There are examples in the UK however many examples are in other parts of the world, especially where space and drinking water is at a premium (such as Japan).

## REGULATORY ISSUES



### 3. Regulatory issues

The use of greywater and rainwater recovery systems is comparatively rare in the UK and the level of regulatory control reflects this low take-up. However there are certain very important regulatory issues that will need to be taken into account at the design stage.

It is not the intention of this document to go into great detail about the various regulations. All reference to statutory instruments is referenced so that readers can obtain the relevant documents and find further information if so required.

#### 3.1. Water quality regulations

Regulation for waste water reuse systems is based around ensuring human health and safety through water quality guidelines.

In England the main statutory instrument is the Water Supply (Water Fittings) Regulations 1999<sup>1</sup>. These regulations deal with the need for backflow protection such as air gaps which vary in type depending on the quality of water stored in the tank, and the need for approved materials to be used for all components.

If reused water is to be used for drinking or any other potential human consumption, it will be subject to the Private Water Suppliers Regulations 1991<sup>2</sup>. Since it is not recommended that greywater or rainwater be used for drinking unless an alternative supply is unavailable, this is unlikely to apply to any potential systems installed at Birmingham Eastside. The Water Supply (Water Quality) Regulations 1989<sup>3</sup> will also apply to any systems that supply potable water or water that is used to irrigate food crops.

Like all water systems, greywater and rainwater systems involve the transmission and storage of water, and therefore the risk of Legionnaire's disease should be assessed for each system. In particular, the HSE's Approved Code of Practice and Guidance (ACoP)<sup>4</sup>, and CIBSE's Technical Memorandum 13<sup>5</sup> should be complied with.

It is extremely important to avoid cross contamination of the potable and non-potable water systems where two systems exist. In order to ensure that this is not done accidentally, all non-potable pipework must be labelled clearly, as recommended by the Water Regulations Advisory Scheme (WRAS)<sup>6</sup>.

#### 3.2. Water quality standards

One of the major barriers facing use of greywater and rainwater systems is the lack of a statutory quality requirement for reused water. This makes adequate specification of the system very difficult, and leads to confusion as several different standards have been proposed by different organisations. The majority of the studies available conclude that it is best to operate a Hazard Assessment Protocol, to determine the level of risk of exposure and therefore the level of treatment required.

The Water Regulations Advisory Scheme (WRAS) has produced an excellent document<sup>7</sup> regarding 'Reclaimed Water Systems' which recommends different levels of treatment depending on the use of the water. The types of use are classified as Class A (potable) and Class B (non-potable) as in the Water Supply (Water Quality) Regulations 1989. The classification is summarised below:

- Class A – supplies to kitchen taps, drinks machines etc, basin taps, baths, showers or Jacuzzis, any spray systems such as cooling towers, pressure jetting etc.
- Class B – Other water uses including WC flushing, irrigation and laundry.

The two classes of use will require different treatment, with Class A uses requiring much more stringent treatment and checking of quality. Appendix A: Recommended Water Quality Standards for Different Water Uses reproduces the recommended treatment requirements for each type, after CIRIA 2001<sup>8</sup>.

Some documents also suggest that different levels of risk and therefore treatment will apply depending on whether the system is applied on the level of a single building or household, or shared between one or more buildings or households. This is linked to the level of responsibility that users can be expected to exercise over their system. This is a less precise measure and will be difficult to set standards for at the specification stage, therefore it is recommended that the former, risk based approach be adopted.

<sup>1</sup> HMSO. 1999. Water Supply (Water Fittings) Regulations 1999. SI No. 1148, No. 1506.

<sup>2</sup> DoE. 1991. Private Water Supplies Regulations 1991. SI No. 1991:2790.

<sup>3</sup> HMSO. 1999. Water Supply (Water Quality) Regulations 1989 Amendment 1999.

<sup>4</sup> HSE Approved Code of Practice and Guidance (ACoP), Legionnaire's Disease: The control of legionella bacteria in water systems" (rev 2000).

<sup>5</sup> CIBSE TM13 "Minimising Risk of Legionnaire's Disease" (rev 2000)

<sup>6</sup> Water Regulations Advisory Scheme. 1999. no. 9-02-05. Information and Guidance Note: Marking and Identification of Pipework for Reclaimed (Greywater) Systems.

<sup>7</sup> Water Regulations Advisory Scheme. 1999. No. 9-02-04 Information and Guidance Note: Reclaimed Water Systems, Information about Installing, Modifying or Maintaining Reclaimed Water Systems.

<sup>8</sup> CIRIA. 2001. Rainwater and greywater use in buildings: Best practice guidance

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### 3.3. Other regulations

Although the regulatory framework is minimal for specific greywater and rainwater use, the systems will be subject to a number of other regulations as with other water storage and circulation systems. The systems will be subject to the Building Regulations, particularly where changes or additional loadings to the building structure are imposed. Various components of the systems will also be subject to separate regulations and British Standards including electrical elements, tanks and cisterns, disinfectant systems, and distribution pipework. These will be familiar to all building services engineers and therefore are not discussed in further detail in this document.

## POTENTIAL FOR APPLICATION BY SECTOR



## 4. Potential for Application by Sector

The potential for the use of water reuse systems will depend to a great extent on the type of building, which relates to the function of the building and the number of occupants.

In order to identify the potential for application on each type of building that is likely to be found on the Eastside development, a number of sources of information and publications have been used. To avoid confusion, these have not been referenced individually but have been listed in Appendix C: Further Information Sources.

### 4.1. Water efficiency

Despite the fact that water reuse systems will be more cost effective for less efficient, existing building, it is not recommended that a water reuse system be applied to an inherently inefficient building. Water efficiency is not a technological solution that can be used to promote the 'green' credentials of a building, nevertheless it is certain that efficiency is by far the best method of saving water in any building.

Savings of 30% or more can be achieved even on new buildings by installing carefully selected water efficient sanitaryware, over and above the minimum standards required by the Water Regulations 1999. Sanitaryware such as the following is readily available in the UK at minimal additional cost on specification:

- Dual flush WCs
- Aerating showers with reduced flow rates (max 9 litres/minute)
- Aerating or spray taps with reduced flow rates
- Proximity urinal controls or waterless urinals

With savings of this nature, water efficiency should always be the first resort when seeking to reduce water consumption on any site. Although this study is intended to outline the opportunities available for water reuse, water efficiency should always come first and is a pre-requisite before consideration of a water reuse system.

### 4.2. New and existing sites

Water reuse technologies are much simpler to install in new buildings. This is because the infrastructure pipework and storage tanks for water can be designed in to the new building without difficult modifications. If underground tanks are preferred, these can be installed during excavation works and if they will be at high level in the building, the structural loading can be designed to support them.

One of the key benefits of water reuse systems is their ability to reduce total waste water volume, thus reducing the size of any infrastructure works and therefore capital cost. In existing buildings or sites, the infrastructure will already be present therefore this benefit is not realised.

Conversely, new buildings are much more water efficient than existing buildings, therefore the economics of installing a water reuse system much less beneficial. A building that uses much water for flushing WCs and urinals will achieve much better simple payback than an efficient building.

### 4.3. Residential buildings

The residential sector is the sector where the majority of attention for rainwater and greywater systems has focused to date. There are numerous case studies of installed systems on individual family dwellings, although the majority of installations on multiple dwellings have been on housing association owned properties as demonstration projects or part of a 'sustainable package'.

#### 4.3.1. Individual dwelling systems

The majority of greywater and rainwater systems available 'off the shelf' in the UK are intended for use at the level of a single domestic household. They harvest water from the roof and/or bath and shower, and reuse in the WC after appropriate treatment. In order for such systems to operate effectively they must have sufficient space for an individual system to be installed for each housing unit, especially the space for an individual tank.

The use of rainwater systems is well accepted for individual houses, from garden water butts to simple rainwater storage and reuse systems. The volume of storage is key to the cost effectiveness of the system. If too little, then rainwater will run to waste and will offset little of the dwelling's needs. If too much, the tank will have a large capital cost which will result in unacceptably long payback times. There are various sizing tools available on the internet, including several proprietary systems, to allow an optimum size to be calculated.

Rainwater systems are well suited to supplying irrigation, WC and laundry needs within a dwelling, as long as storage systems can be optimised.

Greywater systems have been applied almost exclusively at the level of a single dwelling in the UK. This is partly due to the acceptability of 'shared' waste water reuse systems being considered unacceptable to the

UK housebuying market. Whether this is a true reflection of the market or not has not been objectively investigated therefore cannot be corroborated.

Greywater systems require much smaller storage vessels than rainwater systems, as the water is generated constantly throughout the year and used almost immediately. The maintenance of such systems is extremely important if they are to operate correctly and safely, including cleaning filters and replenishing disinfectant, and as this will be the responsibility of the homeowner this can be a concern.

There are several proprietary 'off the shelf' systems that are available in the UK, all work on similar principles involving filtration and disinfection before reuse.

*Case study: A two year trial of greywater systems carried out by the Environment Agency found that the savings from such individual systems were very variable, with water savings between 5.6 and 32.2%.*

#### **4.3.2. Shared residential systems**

Shared residential systems are appropriate to multi-residential buildings such as apartment buildings or terraced dwellings where the roof area and storage per unit would be too limited or problematic to justify an individual system.

Rainwater systems will often be less appropriate for these buildings as the ratio of roof area to water demand will be unfavourable. If surface water can also be collected and stored (simpler in new developments) then this can potentially add to the volume of water collected, otherwise the system payback can be unacceptably high.

*Case study: Project Jigsaw, Castle Vale, Birmingham, has partially replaced mains water with rainwater harvested from the roof. The system collects rainwater, filters out leaves and debris, and stores it in a series of underground tanks (45,000 litre total capacity).*

Greywater systems have rarely been applied at this level in the UK despite their frequent application in other countries such as Japan. This is often attributed to the unacceptability of such systems to the UK housing purchaser, and the level of maintenance that would be required by a landlord or other responsible body. Certainly it is more difficult to ensure the quality of the water input to the system, and as there is the chance that contamination of the water collected might occur, treatment and monitoring of the waste water would have to be more stringent.

*Case study: Beddington Zero Energy Development (BedZED) includes a treatment plant that treats waste water from residential and commercial properties to produce non-potable 'greenwater' which is stored and blended with collected rainwater prior to recycling for toilet flushing and garden irrigation. The main treatment plant, known as the Green Water Treatment Plant (GWTP) is housed in an elevated greenhouse and incorporates a "Living Machine" type system which combines the latest developments in ecological engineering with traditional waste water treatment. The system uses hydroponics, where plants are supported on the water surface with their root systems extending into the depth of the tank and contributing to nitrogen and phosphorous removal.*

#### **4.4. Community buildings**

Community buildings include schools, libraries, places of worship and community centres. They can be difficult to make calculations of potential for, as occupancy is variable and unpredictable, and they can be unoccupied for extended periods of time. However the systems can provide a useful learning tool for certain buildings.

Rainwater systems have been applied to community buildings in the UK. The water is perceived to be a 'clean' source and as maintenance is generally carried out for the whole building, this is not seen as a particularly onerous task. Tank sizes need to be relatively large, however since a great proportion of the water used in community buildings is for flushing WCs and urinals, the potential for saving is proportionately greater.

*Case study: Christchurch Junior Replacement School, a new building for 480 children. The installed Monsoon system consists of a 25m<sup>3</sup> underground rainwater storage tank collecting water from a roof area of 1,100m<sup>2</sup>. Rainwater is pumped to a 1.5m<sup>3</sup> header tank situated within the school's roof space via a metered monitoring unit. There are 27 toilets, 4 urinals and 2 external taps connected to the rainwater system. Actual meter readings taken over the last year (2002), indicate that the water consumption in the school is currently 876 litres per person / per year, compared to 3,790 litres per person / per year for the old Christchurch Junior School.*

Greywater is generally not considered an appropriate technology for community buildings. This is due to two reasons; the potential concerns with greywater cleanliness especially where children will be exposed to the water, and the fact that little greywater is actually generated in such buildings, therefore the cost of a system would take a long period to pay back.

#### **4.5. Hotels**

Hotels of all types use a great deal of water in providing services to guests. Unlike the majority of building types, hotels tend to use more water in new buildings than older existing buildings. This is because the

provision of en-suite bathrooms with high performance fittings including power showers, are seen as a major selling point in most hotels.

Rainwater systems serving WCs alone are unlikely to be viable for the majority of hotels unless the hotel has a large roof area and space for large volumes of water storage. If a hotel has a leisure centre with a swimming pool, rainwater could be stored for supply to the swimming pool, offsetting the requirement for top up with mains water. Treatment would be required in order to ensure that the water is of bathing water quality.

Greywater systems are a viable technology for hotels, particularly larger establishments where each room is en-suite. Greywater is generated in large quantities from hotels on a daily basis and this could be treated before use within a short time for flushing WCs in each room. In periods of low occupancy the system could be switched to a mains supply to avoid the potential for storage of water for extended periods. In other countries non-potable water is often supplied to hotel rooms, particularly in arid regions where desalinated water is the principal supply.

Both systems would require an additional water circulation system to be installed throughout the hotel, as the supply of water is widely spread rather than concentrated in one core area. The costs of installation will therefore be relatively high, even for new buildings.

Both greywater and rainwater can be used for irrigation of hotel grounds, though this should be through a sub-surface irrigation system that does not include spray mechanisms.

It is also possible to utilise 'direct reuse' of water in areas such as laundries, where the final rinse water can be reused as the first rinse for the next load. This is a measure that can be specified during the design and fit out of the hotel. In practice however many hotels now outsource their laundry requirements.

#### **4.6. Commercial office buildings**

Commercial office buildings use the majority of water for flushing WCs and urinals, therefore are a suitable candidate for water reuse systems.

Rainwater systems are appropriate for use in commercial office buildings, although their viability will be very dependent on the surface area from which water is collected. Office buildings often have large areas of hard surfacing and if the water can be collected from these areas rather than running to surface water drainage then the system becomes much more viable.

Greywater generation is minimal in office buildings and therefore the cost of the infrastructure and treatment equipment is unlikely to justify the potential savings.

In both cases the layout of the office will have to be considered in viability studies. Often an office building will have more than one 'core' area where washrooms are located, which means that the water circulation will be more extensive. In order to improve viability, the building design could aim for a single, central core which would minimise infrastructure requirements, or could aim to supply just one core area with reused water.

#### **4.7. Industrial buildings**

Industrial buildings can be divided into two distinct elements – the 'process' area where the manufacturing or production takes place, and the 'office' area where administration takes place. Industrial buildings are generally suited to the use of water reuse technologies, because they often have a large roof surface area and because water can be harvested from the 'process' area.

Much of the potential for industrial buildings depends on the type of process that is carried out. For example, if the process results in a liquid waste stream that is slightly contaminated i.e. cooling water then this water could be stored for use either in the process or in the office areas for flushing WCs.

Rainwater systems may also be viable for industrial buildings due to their large roof surface area, and could be mixed with low contaminant waste water from process use to provide additional resources.

Greywater as defined by this report i.e. from human bathing is minimal in an industrial building therefore this technology is unlikely to be viable.

#### **4.8. Retail buildings**

Retail buildings can comprise so many different types that it is difficult to classify their potential simply. A single retail unit is likely to be included in a larger mixed use development including residential and potentially commercial uses. Treatment of the retail unit individually is unlikely to be possible in this case.

Where a retail development is larger there may be the potential for water reuse systems. A shopping centre will benefit from large roof and hard surfacing areas from which rainwater can be harvested, and often from underground parking areas where water can be stored without taking up expensive high grade floor area.

As with office buildings, the need for a wide distribution network can be minimised during design by grouping core WC areas together, or by supplying one core only. Rainwater could also be used for irrigation of internal and external planting, although no spray irrigation should be used.

*Case study: Merry Hill (a shopping centre at Brierley Hill in the West Midlands) collects rainwater from roof areas and stores for use in one core washroom area to supply WCs.*

Due to the minimal greywater arising in a solely retail development, this would not be a viable technology in the majority of centres, unless a particular process on site was found to have a waste water stream that could be utilised i.e. condensate from cooling plant.

#### 4.9. Leisure buildings

The potential viability of water reuse will depend on the precise nature of the leisure facilities available in the building. In the case of health and leisure clubs, these schemes will generate relatively large volumes of greywater from showers, which could be treated and stored for reuse in WCs.

Leisure facilities with large surface area for roofs i.e. sports halls, theatres etc or hard surfacing i.e. tennis courts, hard football pitches etc could recover rainwater for use in WCs or in swimming pools.

In general both rainwater and greywater systems would potentially be viable for leisure buildings. Each should be assessed on a case-by-case basis depending on the exact nature of the activities and building. Consideration at a very early stage is beneficial to allow layouts and location of infrastructure to be carefully planned.

#### 4.10. Mixed use development

Mixed use development has perhaps the best potential for use of both greywater and rainwater systems, as water generated in one type of building (such as hotel greywater) could be reused in another (such as an office building).

The sections above show that high volumes of waste water generation do not always match high potential for waste water usage, either because of use patterns or acceptability. In mixed use developments these can be matched so that generation and use can both be optimised, making the systems much more viable.

In practice however this is not as easy as it appears, and this is mainly due to varying tenancy and maintenance patterns, and structuring of costs. A hotel may share a building with an office development, but they may be tenanted and managed by different organisations. Tenure and management plans will have a major effect on the viability of such systems and will need to be taken into account before a water reuse system can be considered.

#### 4.11. Public open space

Public open space can utilise waste water for irrigation or supply of water for public WCs. It is unlikely that the open space itself will generate much waste water, unless there are large areas of hard surfacing from which rainwater could be harvested.

The use of waste water for open space will therefore depend on surrounding buildings and hard surfacing for generation of water, and management and cost charging mechanisms would have to be agreed.

The other barrier to potential for open space is the need for considerable volumes of storage. Open spaces do allow for the possibility of surface water storage, such as balancing ponds or lakes which can also be a valuable amenity and wildlife benefit. If the open space is associated with a building that has, for example, underground car parking, then it may be possible to utilise this space for tank storage.

The use of waste water in areas where members of the public including children have open access is a risk that can be to some extent designed out by, for example, sub-surface irrigation systems and high quality treatment systems. However it is likely that greywater will be perceived as a less appropriate technology for public access areas where labelling of risk warnings will be difficult.

#### 4.12. Summary of waste water reuse potential by sector

Key	Sector	Rainwater	Greywater
✓✓ High potential	Single residential	✓✓	✓
✓ Potential	Shared residential	✓	?
? Variable	Community buildings	✓	✗
✗ Low potential	Hotels	✓	✓✓
✗✗ Unsuitable	Commercial office buildings	✓	✗✗
	Industrial buildings	✓✓	?
	Retail buildings	?	✗
	Leisure buildings	✓	✓
	Mixed use developments	✓✓	✓
	Public open space	✓✓	✗✗

## POTENTIAL FOR BIRMINGHAM EASTSIDE



## 5. Potential for Birmingham Eastside

The potential for water reuse is a function of:

- The type of buildings at Eastside and their characteristics;
- The number of occupants who will occupy these buildings;
- The volume of space available for water reuse systems;
- Climatic conditions, especially annual rainfall.

As far as possible, this investigation has aimed to identify the answers to these questions, however the stage of development of Birmingham Eastside has meant that in many cases, assumptions have had to be made. In this case they have been stated clearly so that where necessary they can be replaced with more accurate figures at a later date.

Although the masterplan exists and development of some areas has begun (i.e. Masshouse), it has not yet been adopted and detail is still lacking in some areas. The potential for water reuse has been considered on a broadly sectoral basis to allow this report to be applied to any potential development on the site, with examples included where possible to illustrate the potential. The sectors considered follow those listed in the previous section where their general suitability for waste water reuse is discussed.

### 5.1. Climatic conditions

The rainfall data for the Midlands is averaged at 785mm/year (Meteorological Office data 1971-2000), relatively well spread over the year. The rainfall in the Midlands is not subject at present to the extremes of weather found in other parts of the UK notably the south-east, where heavy winter rainfall and very low summer rainfall are experienced.

The spread of rainfall over the year is beneficial to rainwater recovery systems as it allows a smaller tank to be used, and more use to be made of rainwater over the year.

### 5.2. New and existing sites

The Birmingham Eastside regeneration area is made up of an existing development that will be subject to new building (following demolition of existing structures) and reuse of existing structures. In this respect it will function as both new build and refurbishment.

This is beneficial in terms of total water efficiency across Eastside, as in both cases new sanitaryware and systems are likely to be installed. This could be further strengthened by recommendations to developers on water efficient equipment (already included in the Eastside Sustainability Vision) or water benchmarks for different building types.

In terms of viability of waste water reuse systems, this is not beneficial for two reasons; firstly the high water efficiency of the building will reduce the cost savings that could accrue from installing a reuse system, and secondly it is likely that the majority of buildings will reuse the existing sewerage and surface water drainage infrastructure and therefore any savings from reduced infrastructure requirements will not be realised.

The storage of water for reuse may also be problematic on the Eastside development. Existing buildings that will be refurbished may not have structural capability to support large roof level water storage tanks. Similarly, unless a building already has an existing basement then excavation will be less likely on an existing site. It is also apparent from the site visit and map information that there is little open space currently at Eastside where surface water storage in ponds or lakes could be located. However the Environment Agency will continue to promote the use of sustainable surface water drainage systems on new development in Eastside where it is considered appropriate to do so.

### 5.3. Residential buildings

The masterplan and vision for Eastside states that there will be 3,500 new homes on the Eastside site when completed. It is the intention that residential development will be part of the commercial element of the site and will include student accommodation, affordable housing and private homes for sale.

#### 5.3.1. Individual dwellings

It is evident from an examination of the masterplan for Eastside, that there will be few individual dwelling buildings constructed upon the site. Mixed use buildings and apartments will form the bulk of the residential accommodation on the site which are generally unsuitable for the use of individual dwelling rainwater and greywater systems as described in section 4.3.1.

If individual dwellings are constructed at Eastside, individual rainwater and greywater reuse systems would be highly suitable for use. Certainly all individual homes should have at the least, water butts to collect rainwater for irrigation (this is also an EcoHomes credit), but more sophisticated systems could also be considered.

**Example: Rainwater system for an individual home**

2 person home with garden and standard sanitaryware in line with Water Regulations.  
Roof area 70m<sup>2</sup> assuming that whole roof area is used for collection, with a 500 litre tank used for garden irrigation and WC flushing.

Assume system cost of approximately £400.

Water savings approximately 19m<sup>3</sup> per year.

Cost savings approximately £25 per year.

**Simple payback = 16 years**

Greywater systems have been used almost exclusively at this scale in the UK and have been found to be cost effective and suitable for single dwelling use. They do require ongoing maintenance and would malfunction and fail without this attention. Therefore it is not recommended that they be installed at the design stage without the agreement of the occupant or without a third party maintenance agreement.

**Example: 2 person home with standard sanitaryware in line with Water Regulations**

Greywater system used for flushing WCs only

Assume that all greywater is harvested and offsets all WC flushing requirement (i.e. best case scenario)

Assume system cost of approximately £1000\*

Water savings approximately 17.5m<sup>3</sup> per year.

Cost savings approximately £22.70 per year.

**Simple payback = 44 years**

\*This does not include any operating cost or maintenance.

**5.3.2. Shared residential systems**

The majority of dwellings at Eastside will be multi-residential buildings, primarily apartments. Such buildings are suitable for rainwater reuse systems although they often have restricted roof areas (with higher rise apartment buildings) compared to the use patterns. This is not always the case, and as in the example below, on Eastside the existing buildings are actually medium rise with relatively extensive roof areas. This is likely to make the technology more suitable on the Eastside development. In addition, many of the existing warehouse type buildings that are to be refurbished will have semi-basement areas that could be used for the storage tanks.

**Example: Typhoo Wharf redevelopment, 325 new apartments within existing structure.**

Assumed occupancy 650 persons (dwellings only) with an assumed roof area of 10800m<sup>2</sup>.

Total rainwater system cost assuming 6000 litre basement storage tank £2100 (manufacturer's quote)

Assumed additional pipework and infrastructure cost £32,500 (£100 per dwelling)

Water savings approximately 8700m<sup>3</sup> per year.

Cost savings approximately £11,320 per year.

**Simple payback = 3.1 years**

NB No maintenance and operating costs have been included, these would have to be accommodated in a service charge.

As this example shows, if the space and the roof area is available for storage and collection, as in the case of the Typhoo Wharf development, this technology can provide a competitive level of saving and would be a viable technology. Mains water top up would still be required to supplement the rainwater supply, however the planning constraints plan shows a well at the Typhoo Wharf site, plus the canal is in close proximity to the site. Either of these sources could potentially be used as a source of non-potable water to top up the supply. The Environment Agency should be consulted if such abstractions are planned, plus British Waterways if the source is one of the canals that run through the site. The Environment Agency welcomes any pre application discussions any such abstractions may require prior formal consent.

Greywater reuse is considered to be a less viable technology for shared residential systems, due to the difficulty of controlling the water quality and the potential low acceptability of such a system. There are examples in the UK of such systems in use on student accommodation, with varying degrees of success. The problems seem to be related to the low quality of the recovered water which has led to clogging of the system and continual operating difficulties. One reason for this may be that students do not have a 'vested interest' in the system operating correctly and there is anecdotal evidence of accidental misuse of the system i.e. washing plates in hand basins etc.

The one documented case study of a shared greywater system that could be found showed that the operational costs exceeded cost savings, therefore the system did not result in any savings whatever. The use of this technology for multi-residential buildings on the Eastside development is therefore less viable than rainwater systems.

**5.4. Community buildings**

The number of community buildings to be constructed on site is unknown at present, however it is well documented that the flagship new library will be one of the leading examples of new architecture on the site. This building provides a less than ideal example for rainwater collection, due to the proposed roof

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garden that will absorb much of the rainwater falling on to the building roof. However approximately half of the roof (estimated at 12,500m<sup>2</sup>) will be glazed or solid, and could therefore be used for rainwater capture, which is a significant amount.

**Example: Birmingham Library**

Potential rainwater harvest assuming 12,500m<sup>2</sup> roof area = 6680m<sup>3</sup>/year.

Assume 50% of potential water used = 3340m<sup>3</sup>/year.

Assume all rainwater collected used on site for WC flushing and irrigation.

Assumed cost for pipework, storage tank and automatic control of system = £30,000

Water savings approximately 3340m<sup>3</sup>/year

Cost savings approximately £4345 per year

**Simple payback = 6.9 years**

NB No maintenance or operating costs have been included in the calculations

As there will be little or no greywater arising in the community buildings, together with the perceived risk of these systems, it is assumed that there will be little scope for such systems on the Eastside development.

### 5.5. Hotel buildings

Hotel buildings are well suited to the use of reused water, however they have wide distribution networks for the supply of non-potable water to each room, therefore the capital and operational costs will be higher than buildings with compact distributions.

A recent study of water use in existing hotels<sup>9</sup> found that the average water use was approximately 388 litres per guest per day. Although these were existing hotels, this is a fair approximation, as new, high specification hotels would be expected to have a high water use for luxury fittings such as power showers.

The 350 bed hotel at Masshouse might therefore reasonably be expected to use approximately 102m<sup>3</sup> water per day, assuming that the rooms are 75% utilised. Given the typical patterns of use of hotel accommodation, the following assumptions have also been made:

- 50% of water used in baths and showers, generating greywater (51m<sup>3</sup> per day)
- 30% of water used in WCs, potentially could be sourced by greywater or rainwater (30.6m<sup>3</sup> per day)

The hotels at Eastside are likely to be relatively high rise, with restricted roof areas compared to the number of guests accommodated. This will mean that the viability of a solely rainwater system will be reduced as the distribution system will be costly compared to the value of water saved. This is demonstrated clearly by the example below. In practice given the long payback it would be more sensible to supply only a limited area with rainwater, that closest to the storage facility, which would reduce the cost of the distribution network and thus the payback time.

**Example: 350 bed hotel with roof area of 3,000m<sup>2</sup>**

Rainwater harvested approximately 1,640m<sup>3</sup> per year.

Assume all rainwater collected used on site for WC flushing or irrigation.

Assume cost for central storage and control system = £30,000

Assume cost of distribution network = £52,000 (£150 per room)

Water savings approximately 1,640m<sup>3</sup> per year

Cost savings approximately £2133 per year

**Simple payback = 38.4 years**

NB No maintenance or operating costs have been included in the calculations

It is evident from the assumptions listed above that in theory it would be possible for a hotel to supply all of their requirements for WC flushing with greywater generated on the premises, with the excess being used for irrigation or diverted to foul sewers. The cost of a system is difficult to estimate as such a system has not been installed previously in the UK, but even with conservative estimates as shown in the example below, the payback time is reasonable.

**Example: 350 bed hotel at 75% occupancy.**

Waste water generated: 18,615m<sup>3</sup> per year

Water saved: 11,169m<sup>3</sup> per year

Assumed cost of capital infrastructure i.e. tanks, treatment, controls etc: £100,000\*

Assumed cost of distribution network i.e. pipework etc: £52,500 (£150 per room)

Cost savings approximately £14,530 per year

**Simple payback = 10.5 years**

\*Estimated at high cost due to the likely high quality treatment required.

NB No maintenance or operating costs have been included in the calculations

<sup>9</sup> Environment Agency and multi-sponsor research project. May 2003. Water Demand Management in the Hotel Sector through Demonstration Projects. Unpublished Sponsors Report.  
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### 5.6. Commercial office buildings

Commercial office buildings generate very little greywater therefore the only potential at Eastside is the use of rainwater harvesting systems. As demonstrated by the hotel example above, the area of the collection zone will be critical to the commercial viability of the scheme. The hotel example is very close to the payback that would be anticipated for a commercial office system, where 100% of the rainwater collected would be expected to be used in flushing WCs, with a mains connection to supplement the supply.

As with hotels, it would be appropriate to consider supplying only part of the building (i.e. the core area closest to the supply) with rainwater rather than installing a wide distribution network.

The main difference with a typical commercial office scheme would be the potential use of the hard surfacing for the car park as well as the roof area. This could have a major effect on the viability of the system. However on Eastside there is a desire to limit the level of car parking to promote more sustainable forms of transport. This is to be encouraged as the benefits of recovering rainwater would in no way compensate for the CO<sub>2</sub> emissions from private car use.

The viability of a rainwater system should be evaluated for office buildings on a case-by-case basis taking into account the potential of rainwater collection from all hard surfaces.

### 5.7. Industrial buildings

Industrial buildings are likely to be few on the Eastside development, with manufacturing minimal and commercial use limited to warehousing and studio type production. Bulk manufacture using considerable volumes of water is likely to be rare.

Where this occurs however, the manufacturer should be encouraged to identify ways in which waste water streams could be reused in the building either for process or 'domestic' use. Envirowise ([www.envirowise.gov.uk](http://www.envirowise.gov.uk)) provide a free service that provides advice to industrial water customers to help minimise waste water. If industrial units with large roof areas are planned, the potential for rainwater reuse should be considered at an early stage.

### 5.8. Retail buildings

The existing masterplan makes provision for retail development on the site, however it would appear that this is solely limited to inclusion within other developments including leisure, residential and commercial. This is due no doubt to the proximity of the site to the retail development at Martineau Galleries and the Bullring as well as the city centre. For this reason this sector has been discussed in the section below covering mixed use developments.

### 5.9. Leisure buildings

The Eastside masterplan and the currently planned development on the site includes a considerable amount of leisure including health and fitness facilities, cafés and restaurants and other similar building types, to augment the existing Millennium Point leisure complex.

It is difficult to make general statements about leisure facilities as they are so varied, however all leisure facilities share certain elements in common; they use much water for flushing WCs and urinals in washrooms, and they all have a need for summer cooling to deal with high occupancies.

Rainwater systems are potentially suited to the supply of cooling systems as the water is relatively clean without excessive treatment. It is also suited of course to supplying WCs. Unless the collection area is very large, the rainwater collected will only supply a portion of the total water requirement. The example below shows how a large surface area can lead to considerable water saving for leisure premises.

**Example: Millennium Point with a roof and hard surface area of approximately 16,000m<sup>2</sup>.**

Assuming that 50% of the rainwater can be recovered (some losses from hard surfacing) = 6280m<sup>3</sup> per year

Assume that all rainwater recovered can be used in the building\*

Cost of storage and collection system assumed as £50,000

Water saved approximately: 6280m<sup>3</sup>/year

Cost saved approximately: £8170 per year

**Simple payback = 6.1 years**

\*Not unreasonable given that WC and urinal flushing will be considerable in leisure facilities.

NB Operating and maintenance costs have not been included in the calculations

Where a large surface area is available, either roof or hard surface, then it would be worth considering the potential for rainwater collection for use in leisure facilities.

Greywater is variable in potential, as in some types of leisure facility such as restaurants there is little usable greywater. In some, such as health centres, there will be some generation from showers and there are benefits here, as the generation and use will be in relatively close proximity to each other (changing rooms) therefore the circulation requirements are minimal.

**Example: Health club with 10 showers, each used 30 times per day for 5 minutes**

Total greywater generated approximately 4925m<sup>3</sup> per year

Assume that all greywater can be utilised on site for WC flushing, either within the club itself or in associated café areas.

Assume cost of storage and treatment system, with limited distribution network = £50,000

Water saved approximately 4925m<sup>3</sup> per year

Cost saved approximately £6407 per year.

**Simple payback = 7.8 years.**

NB Operational and maintenance costs are not included in the calculations

**5.10. Mixed use development**

In theory a mixed use development offers the best potential for both greywater and rainwater use. This is because as the previous sections show, waste water is not always generated in the buildings where it can best be utilised. For example, a hotel generates a great deal of greywater, however due to the wide distribution network that would be required in order that the treated water can be supplied back to WCs, the capital costs are very high. Ideally, this generated waste water would be used in another building close by, where there is a more compact distribution network.

The example below explores the potential for use on the Masshouse site, as this is a building where the areas and likely occupancy are known. Other sites at Eastside are very likely to be equally suitable (Canal City, Warwick Bar etc) however their usage is less well defined at present.

**Example: 350 bed hotel at 75% occupancy and 41,000m<sup>2</sup> office space at Masshouse (4100 occupants at 1 person per 10m<sup>2</sup>)**

Greywater arising from hotel assumed to be 18,615m<sup>3</sup> per year

Requirement for WC flushing in office space (5 days per week assumed) 24,796m<sup>3</sup> per year

Assume cost of storage and treatment system = £100,000\*

Water saved approximately 18,615m<sup>3</sup> per year

Cost saved approximately £24,220 per year

**Simple payback = 4.1 years**

\* High cost assumed to obtain very high quality end product

NB Operational and maintenance costs are not included in the calculations

It would also be possible to collect rainwater from the roof of the development and mix this with the greywater to provide additional waste water. The water treatment provided for greywater would be more than sufficient to treat the rainwater additionally, however the additional capital cost of distributing and storing the rainwater may not benefit the total payback time.

In practice, this sharing of waste water to provide a source of potable water is not often possible. This is due to the varying tenancy and maintenance patterns within a building, and particularly the difficulty with cost sharing. Although the Masshouse building used in the example is being built by a single developer, there is a likelihood that the hotel will be operated and maintained by a single hotel group, whilst the office space may be tenanted by one or more commercial tenants unrelated to the hotel group.

In order to facilitate sharing of water systems, these would have to be the property and responsibility of the landlord, and any ongoing costs paid to the landlord through a service charge or metering arrangement. Access to pipework and other equipment would have to be available to the landlord. Tenants may be unwilling to delegate this level of maintenance over essential services to the landlord, and landlords may well be unwilling to accept this level of responsibility.

Early discussions with the developer and prospective or secured tenants would be beneficial to the promotion of such schemes.

**5.11. Public open space**

Public open space can be supplied with waste water for irrigation purposes, this can be supplied to plants and lawns via a sub-surface irrigation system or 'trickle system' which delivers water directly to the root structure in the soil. When combined with a soil moisture sensor and control system so that they only operate when required, these systems can be very efficient and are likely to provide better irrigation than sprinkling or hand watering.

For reasons of risk and maintenance, greywater systems would be unsuitable for use in public open spaces for irrigation, however rainwater is a better option and is thought to be more beneficial to plants than watering with mains supplies.

The two issues that need to be overcome before these systems can be used are the source of the water and the storage of the supplies. The source of the water would have to be nearby buildings or hard surfaces, therefore the open space would need to be near to such sources. The storage is more of a

problem, given that in order to provide useful volumes of storage throughout warm summer months, the storage would need to be considerable.

In the case of Eastside, the City Park area would provide an ideal location to use rainwater for irrigation. In the first place there are several ready sources of rainwater in close proximity to the park:

- New City Gate office developments lining the park
- Parcelforce depot (to be redeveloped), with a large roof area of approximately 14,000m<sup>2</sup>
- Library development
- Millennium Point roof and hardstanding
- New boulevard road which could be used to harvest rainwater.

In terms of storage there are two main options. Firstly, water could be stored in large tanks within the underground car park that is intended to underlie the City Park. Although these would take up some space reducing car parking, this is a relatively 'low value' space compared to commercial space and therefore would have fewer cost implications. Being at low level, the rainwater could flow to the tanks under the influence of gravity rather than needing pumps, and the sub-surface location would help to maintain cool water temperatures.

Alternatively, water could be stored in surface drainage systems such as infiltration trenches placed at the side of the boulevard road. Water would be stored in the interstitial spaces between aggregate and could be pumped out for use in irrigation. These surface water drainage features would be unlikely to be adopted and therefore maintenance agreements and responsibility would have to be negotiated (see section 8).

Public open space could also be used to store rainwater prior to use in buildings. This would be in the form of a storage lake or pond. The plans for the City Park do not include a large body of water, and it would appear that the only appropriate place where such a body of water could be planned is the Warwick Bar area, where the Grand Union Canal and River Rea intersect. At present this is an area of unmanaged open space, however it is planned that it should be an area of waterside leisure and residential buildings. If space could be allocated for a body of water this could be used to store rainwater from the surrounding buildings. It would also be useful to alleviate potential flooding since this area is within the River Rea fluvial flooding region, whereby water could be stored in flood and either used in surrounding buildings or discharged to the river when floods subside.

The location of a surface water lake here may also have benefits for the potential hydro system at Montague Street, further downriver along the River Rea. This hydro station may benefit from the storage of water when water levels are high, and their subsequent release at lower water flows, enabling electricity to be generated from the enhanced flow.

The Environment Agency supports the use of surface water storage, as this provides attenuation to lessen the increase loading on the receiving watercourse as stated. However the River Rea does suffer from low flows at certain times of the year, so it is essential that the Agency is consulted preferably at the pre-planning stage. The Agency would welcome the inclusion of a storage lake or pond within the City Park.

## KEY DESIGN ISSUES



## 6. Key Design Issues

Rainwater and greywater systems have specific design requirements that need to be taken into account by the developer and design team. There are several excellent publications that assist with the design of such systems, including:

- CIRIA. 2001. Rainwater and greywater use in buildings: decision making for water conservation<sup>10</sup>.
- CIRIA. 2001. Rainwater and greywater use in buildings: Best practice guidance<sup>11</sup>.
- WRAS 1999. Reclaimed water systems: Information about installing, modifying or maintaining reclaimed water systems<sup>12</sup>.

Specific issues that should be considered are also discussed in the remainder of this section, however it is recommended that designers and developers obtain site specific advice from specialist installers or manufacturers before attempting to design such a system.

### 6.1. Cross contamination

This is the main risk issue when designing rainwater or greywater systems. It is imperative that the risk of cross contamination is eliminated, both during initial installation and during future works to the building. There have been various methodologies suggested in the past few years, including the use of different sized pipework for waste water and potable water. The lack of regulation on this subject has exacerbated the difficulty. However recent guidelines<sup>13</sup> have been published which if adopted generally would avoid much of the confusion, regarding clear and unambiguous labelling of pipework and fittings.

In many of the other countries worldwide where greywater reuse has been adopted, such as Japan, the reclaimed water is coloured blue or green by a dye added to the water at distribution. This has the benefit of making it immediately obvious that the water is not potable (highlighting any cross contamination), plus making it appear 'cleaner'. This is used successfully at the BedZed development in London where the water is coloured green and known as 'greenwater' rather than greywater, to emphasise the environmental benefits of the system.

### 6.2. Tank size

One of the key issues to the affordability of a rainwater system in particular is the size of the tank, which is the most costly component of the system. Designers often assume that the larger the tank, the more cost effective the system will be, however this is not the case, and it is important that the tank size is optimised. Many of the manufacturers and suppliers of rainwater systems will calculate the optimum size of tank for the particular needs of the building. Some manufacturers have such calculation tools on their web sites (such as Klargester's Envireau suite of products [www.klargester.com](http://www.klargester.com)) and these are very useful as a first test of affordability.

It is recommended that the designers consult with a specialist installer or consultant to optimise the tank size and reduce capital cost.

### 6.3. Filter type

All water reuse systems use a filter of some type, whether to filter leaves and other debris from the roof (rainwater systems) or bathwater (greywater systems). There will always be a loss of water incurred as a result of any filter use, and the type of filter and its operation can have a significant effect on the cost effectiveness of the system. BSRIA<sup>14</sup> found that backwashing of one greywater filter used so much water that the system payback was effectively negated.

An appropriate assumption for most rainwater filters is to assume that only 70% of the water will reach the system, however the manufacturer or supplier of the filter will be able to suggest a more accurate figure. For greywater systems these can vary so greatly that it is essential to investigate the efficiency on a case by case basis.

### 6.4. Water source area

It is obvious that in rainwater systems the area of surface from which the water is harvested will influence the volume of water available. However it should not be assumed that the entire roof area can be used to collect water. This will depend on the layout of the roof drainage, as it may be uneconomic to collect water from two downpipes located at opposite ends of a very large building, for example.

<sup>10</sup> CIRIA. 2001. Rainwater and greywater use in buildings: decision making for water conservation. ISBN 0 86017 880 3

<sup>11</sup> CIRIA. 2001. Rainwater and greywater use in buildings: Best practice guidelines. ISBN 0 86017 539 1

<sup>12</sup> WRAS 1999. Reclaimed water systems: Information about installing, modifying or maintaining reclaimed water systems. Information and Guidance Note No. 9-02-04. Available online at: [www.wras.co.uk](http://www.wras.co.uk)

<sup>13</sup> WRAS 1999. Reclaimed water systems: Marking and Identification of Pipework for Reclaimed (Greywater) Systems. Information and Guidance Note No. 9-02-05. Available online at: [www.wras.co.uk](http://www.wras.co.uk)

<sup>14</sup> Brewer et al. 2001. Rainwater and Greywater in Buildings Project Report and Case Studies. BSRIA 2001. ISBN 0 86022 577 1

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In addition, the type of roof will have a great influence. A roof with uneven, gravelled surfaces will retain more water on the surface and will be subject to greater evaporation than a smooth pitched roof where water will run off quickly into the tank. Green roofs are beneficial in many ways but will substantially reduce the volume of rainwater that will be harvested from them.

The type of roof will need to be specified or assumed before the rainwater system viability can be estimated.

### 6.5. Quality of runoff

Quality of runoff will influence the amount (and therefore cost) of treatment, the level of maintenance involved and ultimately the quality of the non-potable water supplied.

The obvious solution to impaired water quality is to control the quality of the water running into the system. For rainwater this can be accomplished in the following ways:

- Filters to exclude debris and leaves
- Regular cleaning of runoff surfaces
- Potential control system excluding first runoff after a dry period when roofs will be more contaminated
- Petrol and oil interceptors where runoff from hard surfaces is used, especially car parking and roads

For greywater it could include:

- Exclusion of sources that may potentially be used for non-bathing activities i.e. bathroom/bedroom basins in hotels and student accommodation
- Prominent and simple labelling
- Bypass controls at point of use so that water can be diverted to foul sewers if necessary (much more costly)

In addition to this, disinfection is often used in both rainwater and greywater systems to ensure that any potentially harmful organisms are eliminated before use. The systems should always fail safe i.e. if any disruption of the system occurs, the supply defaults to mains water supply.

### 6.6. Storage of water

The safe storage of water to avoid bacterial growth such as Legionellae is familiar to all designers. The same principals should be applied to any storage of reused water, including that in pipework and tanks as well as surface water bodies.

The general principals include:

- Moderation of temperature (water stored at below 5°C where possible)
- Avoidance of deadlegs in pipework and other circulation networks
- Regular cleaning and checking of quality
- Circulation of water where it may be stored for long periods
- Regular disinfection of fittings by hot water circulation

### 6.7. Groundwater recharge

One of the concerns that is often stated with respect to rainwater systems is the removal of rainwater from the locality (ultimately transferring to the foul sewer), and the effect that this can have on the natural recharge of the groundwater.

In the case of Eastside, this would be of less importance, as the majority of the area is built up and therefore runoff would generally be diverted into the surface water drainage system rather than infiltrating into the ground. In addition, it appears that the ground water under Birmingham is actually rising as a result of reduced industrial abstractions therefore this will not be a concern on the Eastside site, although the Environment Agency should always be consulted before considering a rainwater reuse system. The Environment Agency considers it unlikely that rising groundwater will be an issue across the whole of the Eastside are.

### 6.8. Sewerage flow rates

A concern that is often raised at the design stage of greywater systems is the potential for backing up of foul sewers due to the reduced volume of total waste water as a result of the system. There is no evidence in any of the case studies carried out in the UK to suggest that this has occurred, however the age of the sewers at Eastside would make it more likely to occur. This was highlighted as a concern by the water undertaker (see section 8).

It is recommended that the local sewage treatment company be consulted if a greywater system is proposed, in this case Severn Trent.

### 6.9. Maintenance agreements

Maintenance is absolutely essential if the systems are to operate correctly and safely. This is particularly true of greywater systems but will also apply to rainwater systems though the requirements will be reduced.

If any type of water reuse system is proposed, it is recommended that the responsibility for maintenance be agreed at the earliest stages, and if possible a third party service level maintenance agreement be drawn up. This means that a specific party is responsible for carrying out an agreed level of maintenance at regular intervals. The agreement should also cover who is responsible for carrying out emergency maintenance should replacement of parts be necessary or the system fail for whatever reason, and who will bear the cost.

Ensuring that this type of agreement is in place from the earliest stages will avoid conflict and reduce any risks of the installed system.

#### **6.10. Life cycle costs**

The costs that have been used throughout this document have excluded the costs for maintaining and operating the systems. This is because although some documented information exists on the real costs of operating a system, the case studies show that the costs are not predictable. This may be a result of few case studies being available meaning that patterns cannot be clearly seen. However these costs will need to be taken into account at the design stage and should include estimations of:

- Site preparation costs (i.e. excavation if necessary)
- Purchase of components
- Collection and distribution pipework
- Installation and commissioning
- Consumables such as disinfectants and cleaning chemicals
- Electrical operating cost
- Unplanned maintenance costs
- Cost of maintenance and inspection (incl. any regular water quality checks performed by laboratory)

Case studies of systems can be found in a BSRIA case study report of 2001<sup>15</sup>.

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<sup>15</sup> Brewer et al. 2001. Rainwater and Greywater in Buildings, Project Report and Case Studies. BSRIA. ISBN 0 86022 577 1

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## OTHER ENVIRONMENTAL IMPACTS



## 7. Other Environmental Impacts

### 7.1. Environmentally beneficial materials

The majority of the materials that are used in greywater and rainwater systems are made of plastic. Although certain metals such as copper would be more environmentally beneficial, it would appear that these materials are not recommended for water reuse systems. This is because the water is likely to be more corrosive than standard mains water and will tend to corrode metal parts and pipework.

Below ground clay pipes could be used, although as the majority of the surface and foul water drainage is in place there will be little need for such items at Eastside.

There are several companies in the UK that manufacture plastic tanks and components using recycled materials, although none of the major manufacturers of rainwater and greywater systems consulted use such products as standard.

Birmingham Eastside have recently completed a website that aims to identify local manufacturers and suppliers of low impact equipment and materials. There are several suppliers included on this list that supply recycled plastic products, however it appears that these manufacturers are extremely busy with full order books.

This potentially indicates a low supply and high demand for such products in the Midlands area, which might provide a niche market that businesses on the Eastside development could exploit.

### 7.2. Impact on wildlife

It is unlikely that the use of rainwater or greywater would have any impact on wildlife (see section 8). If surface water lakes or ponds were used on site to balance water flows or store water, this would provide a useful and valuable habitat for birds or other wildlife, and result in a positive impact, particularly if designed sensitively.

## CONSULTATION



## 8. Consultation

The consultation for this study was undertaken to identify any particular constraints on the use of greywater or rainwater for the Birmingham Eastside area. The consultation concentrated mainly upon regulatory and planning matters, rather than issues of acceptability.

The list of those consulted includes:

- Alastair Picken, Iain Baird, Mike Harvett & Olivier Barthelemy, Environment Agency (national strategy for SDS, wider effects of reused water, national water demand management centre)
- Rob Wells & Clive Wright, Birmingham City Council (planning applications and drainage issues)
- Greg Edwards, British Waterways / Watergrid / ISIS (use of canal network)
- Robin Maynard, Drinking Water Inspectorate (issues to potable water systems)
- James Ashton, Severn Trent Water (issues to water company assets)
- Colin Wilkinson, RSPB (Royal Society for the Protection of Birds)
- Chris Parry, Birmingham Wildlife Trust (issues to local wildlife)
- Health and Safety Executive help line

Full details are reported of all conversations and exchanges of information in Appendix B: Records of consultation.

Overall, the feedback from the consultation process was very positive. Many public bodies, although not directly involved in water minimisation issues, do have the remit to promote sustainable development. Reclaimed water systems would be included within this aim and as such the consultees were very encouraging.

### 8.1. Regulatory issues

The only regulations that cover greywater and rainwater systems are those that relate to the use of potable mains water as a back-up, the use of which is recommended by Severn Trent Water. The Drinking Water Inspectorate advised that care must be taken to follow the Water Regulations with respect to the use of air gaps and backflow prevention methods to prevent any potential contamination from greywater/rainwater feeding back into the potable supply. In addition, labelling of pipes and colouration of the reclaimed water itself is also advised.

The Health & Safety Executive advised for consideration to be given to the risk of legionnaire's disease and its prevention. This was the only guidance they could provide on reclaimed water systems and relates to the careful design of systems rather than the feasibility of their use.

Problems could potentially arise with the original combined sewer system, which is currently in place at Eastside. Some of these sewers operate on a self-cleansing velocity, originally designed to accept a certain amount of flow in order to facilitate this. Any reduction in flow could cause blockages in the sewer network so the use of rainwater systems, which would divert runoff away from these sewers, could cause problems. Further investigation would be needed to ascertain the existing situation at the site and whether there would be problems with reduced surface water flows. This could be undertaken in partnership with Severn Trent Water, which has sewer models for some of the area. Net volumes will need to be calculated.

### 8.2. Planning issues

Birmingham City Council Planning Department could not identify any issues with reference to greywater and rainwater systems which would cause concern to the planners, other than issues of development on a certain scale. They would encourage the use of reclaimed water systems within the development and promote the sustainability aspect of the systems.

The Environment Agency would also recommend the use of water conservation measures within the buildings on the site when consulted by the Planning Authority, following receipt of planning applications for Birmingham Eastside. Again, as for Birmingham City Council this is not the Agency's main remit, as much of the emphasis of these system types is within buildings rather than within the external environment. However, the Agency would comment on the use of SuDS at the sites, where possible and appropriate, which could be considered to be reclaimed water systems.

The opportunities for using SuDS within the redevelopment are fairly limited due to the nature of the area and the lack of space. It is already very developed and there is the possibility of contaminated land due to

the past history of industrial uses in the area. In addition, the nearest watercourse is 4m below ground level and there are problems of high groundwater levels in the locality.

New guidance is now available as to the approach for using SuDS on site, with the Framework for Sustainable Drainage Systems in England and Wales now out to consultation. Any opportunities to reduce runoff from the sites should be incorporated into the designs, which could include increased green space and rainwater storage systems.

Adoption of the systems once in place was highlighted to be a problem by the Birmingham Wildlife Trust, which had experience of this on another site in the Birmingham area. Although Severn Trent Water has adopted a few SuDS schemes, it is only up to the point of outfall and even then only for fairly traditional engineering approaches such as oversized pipes. The water company would not take on other, softer SuDS designs such as wet ponds and open swales.

The Drainage Engineer for Birmingham City Council confirmed that SuDS systems would also not be adopted by Birmingham City Council's Leisure Services Department, who look after the Council owned parks and open spaces in Birmingham. As such, it is recommended that the issue of adoption of these types of systems be considered in the early stages of the planning process.

There were no adverse issues on the local wildlife or birds identified by the RSPB or the Birmingham Wildlife Trust. Both bodies considered the use of reclaimed water systems to be a good, and were encouraging of such an approach. The Birmingham Wildlife Trust recommended the use of SuDS where possible, and sent through references and further advice by email, which is included in Appendix B: Records of consultation.

Due to the presence of constraints such as contaminated land, surface water drainage, and rising groundwater, every opportunity for pre planning discussion with the Environment Agency should be taken.

### **8.3. Licensing issues**

If any water is to be taken from an existing water source, e.g. a river, watercourse or groundwater supply, an abstraction licence is required from the Environment Agency. If an existing supply is present, as could have been provided for some of the historic industrial uses on site, then an existing license can be transferred to a new owner.

There are no licensing issues for reclaimed water systems in place at the moment, although if their use becomes widespread then the Environment Agency considered that this could be implemented later. The comment was made that rainwater cannot be licensed as it is a natural phenomenon. Greywater also cannot be licensed as in theory it would originally come from the user.

Any development within 7m of the River Rea would require bylaw consent from Birmingham City Council Drainage Department under its permissive powers as the land drainage authority. This would include outfall pipes or any other infrastructure required for greywater or rainwater systems.

Any development that would affect the canal network or banks would require consent from British Waterways. Through its new company Watergrid, it can also supply water to new developments, at either potable or less treated grades, from the canal network. This could also be used for building cooling systems, as has been done at the Mailbox in Birmingham. The water can be returned back to the canal, provided that the change in water quality and temperature is not too great. Discharge consent would be required from British Waterways to discharge anything back into the canal network, which would include restrictions on water quality. Untreated greywater would not be allowed to discharge into the canal network. . Formal discharge consent may also be required from the Environment Agency for any discharge to controlled waters and possibly the canal network.

## CONCLUSIONS



## 9. Conclusions

Rainwater and greywater systems are a well established technology in other parts of the world and are becoming more widespread in the UK, although there are unspecific concerns about the acceptability of greywater systems to the general public.

The potential for rainwater and greywater reuse systems on the Eastside site is inhibited by the highly developed nature of the site and the existence of a combined foul and surface water sewer.

There is potential for the developers and design teams of certain building types within Eastside to consider use of rainwater and greywater systems. Much will depend on the specific site, tenure and layout, as described in earlier sections, however the potential can be summarised as in the table below.

The table also includes an estimation of the potential payback times drawn from the Eastside examples used within section 5. These are very approximate and do not include life cycle costs, they should be used as a very basic guideline to the potential on the site.

Key	Sector	Rainwater		Greywater	
		Potential	Payback	Potential	Payback
✓✓ High potential	Single residential	✓	16	✓	44
✓ Potential	Shared residential	✓✓	3.1	xx	-
? Variable	Community buildings	✓	6.9	xx	-
x Low potential	Hotels	✓	38.4	✓	10.5
xx Unsuitable	Commercial office buildings	✓	?	xx	-
	Industrial buildings	✓	?	?	?
	Retail buildings	See mixed use development			
	Leisure buildings	✓	6.1	✓	7.8
	Mixed use developments	✓✓	?	✓✓	4.1
	Public open space	✓✓	?	xx	-

Where developments are proposed that fit into one of the building types considered to have potential for water reuse systems, the developers and designers could be encouraged to consider these systems by Birmingham Eastside and Birmingham City Council Planning Department.

All developments will have to assess the potential for water reuse on a site by site basis, and it might be beneficial to assemble a short document including the design issues highlighted in section 6, with a list of local contacts and some details on calculation methods i.e. for rainwater systems. This would enable designers to see quickly whether a system would be viable for their site and whether to investigate it further. This would be particularly suitable for rainwater systems as they are found to be more suitable on the Eastside development.

The feasibility of a rainwater system is directly related to the surface area and usually roof area associated with a building. Buildings (either proposed or existing for redevelopment) with large roof surfaces should be identified and direct engagement with the prospective developers initiated to encourage take up of rainwater systems.

Mixed use developments are considered to be the primary potential for this site, however there are significant barriers to the take up of these systems due to responsibility sharing, tenancy and charging issues. It might be beneficial to bring together Eastside developers and large tenant groups (such as hotel groups) to discuss the issues and methods of overcoming them.

No particularly local manufacturers of water reuse systems have been found, and although there are manufacturers of components such as tanks and pipework in the region, they are apparently extremely busy. This may represent an opportunity for businesses locating at Eastside to exploit a local market for such products, perhaps in alliance with an existing manufacturer or supplier in another part of the UK.

## Appendix A: Recommended Water Quality Standards for Different Water Uses

*After CIRIA 2001. Rainwater and greywater in buildings: Best Practice Guidance. ISBN 0 86017 539 1*

## Appendix B: Records of consultation

## Appendix C: Further Information Sources

HMSO. 1999. Water Supply (Water Fittings) Regulations 1999. SI No. 1148, No. 1506.

DoE. 1991. Private Water Supplies Regulations 1991. SI No. 1991:2790.

HMSO. 1999. Water Supply (Water Quality) Regulations 1989 Amendment 1999.

HSE Approved Code of Practice and Guidance (ACoP), Legionnaire's Disease: The control of legionella bacteria in water systems" (rev 2000).

CIBSE TM13 "Minimising Risk of Legionnaire's Disease" (rev 2000)

Environment Agency and multi-sponsor research project. May 2003. Water Demand Management in the Hotel Sector through Demonstration Projects. Unpublished Sponsors Report.

**CIRIA. 2001. Rainwater and greywater use in buildings: decision making for water conservation. ISBN 0 86017 880 3**

**CIRIA. 2001. Rainwater and greywater use in buildings: Best practice guidelines. ISBN 0 86017 539 1**

**WRAS 1999. Reclaimed water systems: Information about installing, modifying or maintaining reclaimed water systems. Information and Guidance Note No. 9-02-04. Available online at: [www.wras.co.uk](http://www.wras.co.uk)**

**WRAS 1999. Reclaimed water systems: Marking and Identification of Pipework for Reclaimed (Greywater) Systems. Information and Guidance Note No. 9-02-05. Available online at: [www.wras.co.uk](http://www.wras.co.uk)**

**Brewer et al. 2001. Rainwater and Greywater in Buildings Project Report and Case Studies. BSRIA 2001. ISBN 0 86022 577 1**

Butler, D. & Davies, J.W. (2000) Urban Drainage, E & FN Spon, London, ISBN 0 419 22340 1, 485 pp.

Mustow, S., Grey, R., Smerdon, T., Pinney, C., Waggett, R., (1997). Water Conservation - Implications of Using Recycled Greywater and Stored Rainwater in the UK, Final Report 13034/1, prepared by BSRIA for DWI.

Pratt, C.J. (1999). Use of Permeable, Reservoir Pavement Constructions for Stormwater Treatment and Storage for Re-Use. Wat. Sci. Tech., 39, 5, 145-151

Environment Agency. 2003. Harvesting Rainwater for domestic uses.