Water Sensitive Urban Design Guidelines

WSUD

Executive summary

Total Watermark 2004 invites residents, business and the visiting community of the City of Melbourne to help save water, improve water quality and protect our waterways. It sets policies for water conservation, stormwater, wastewater and groundwater.

This document, *Water Sensitive Urban Design (WSUD) Guidelines* gives direction on how to achieve the sustainable water objectives set out in *Total Watermark*.

Urban designers can lead the way by following these guidelines, and help:
* reduce water consumption;
* reduce wastewater;
* maximise water reuse; and
* treat stormwater before discharge to the aquatic environment.

All this can be achieved by following the guiding principles:
* demand management - reducing the demand for
* water in our homes, and businesses;
* 'fit-for-purpose' water use - using appropriate
* quality water for the appropriate purpose;
* alternative urban water sources - rainwater
* harvesting, greywater reuse and blackwater
* reuse; and
* applying stormwater best practice environmental
* management.

These guidelines apply targets to measure our performance against the principles of water sensitive urban design in a range of local scenarios.

The Water Cycle in the City of Melbourne

Port Phillip Bay

The City of Melbourne is working to improve stormwater quality, to help improve the health of Port Philip Bay.

A key focus is the reduction of nutrient loading, toxicants, suspended solids, and litter.

The City of Melbourne is working with stakeholders across catchments to achieve environmental benefits.

Melburnians

Melbourne has a working population of 323,000 - and growing. The residential population is 52,000, but could reach 123,000 by 2020.

The community is always invited to get involved in total water management issues. Community contributions are welcomed by the City of Melbourne.

Evaporation

The sun heats water bodies, causing vapour to rise. This vapour is free of salts and contaminants.

Melbourne has a relatively dry climate with an evaporation of 3.4mm per day, or 1.241m per year.

Rainfall

Currently Melbourne's rainfall is generally moderate and relatively consistent. With more rain falling in winter, approximately 600 - 700mm of rain normally falls in Melbourne. This rainfall has not been achieved in the past eight years and is known officially as a drought period.

Climate change is likely to result in less rainfall in the Melbourne area, which means below-average rainfalls will be more common.

Catchment management and water catchment system

Water supply for the City of Melbourne and all of greater Melbourne comes from nine storage dams, with some top-up received from the Thomson River and the Goulburn River. All catchments are closed to the public, giving us world-class water quality that needs minimal treatment before drinking.

Timber harvesting occurs in some of the water catchment areas. Because young replacement trees use more water than established trees, this can reduce the amount of water available.

Water Supply

The City of Melbourne receives its high-quality water supply from two water retail companies: City West Water and South East Water.

The City of Melbourne, the Victorian Government, water retailers, non-government organisations and community groups strongly encourage water conservation.

Water consumption across the municipality was 19 per cent less in 2003-04 compared to 1999-2000. Our residents are using 40 per cent less water, businesses 12 per cent less and Council 26 per cent less. We need to continue these great savings.

Rainwater harvesting

More rain tends to fall in urban areas than in water supply catchment areas. Rainwater harvesting captures rain from these urban areas, and is then used on-site.

Rainwater tanks reduce demand for potable water, and reduce the amount of stormwater entering our waterways.

Tanks also allow pollutants, such as suspended solids to settle before use.

The City of Melbourne encourages the use of rainwater tanks, noting that they are most effective when plumbed to the toilet.

Water recycling

Water recycling is encouraged to help reduce potable water use. Open spaces, industry, and commercial buildings are particularly suited for water recycling.

Water demand management is always the first approach to water conservation. Water substitution is the next step.

The City of Melbourne encourages fit-for-purpose water use. This means, for example, reducing the use of drinking-quality water in flushing toilets.

Water recycling proposals in the City of Melbourne must be neutral in greenhouse gas emissions. This can be achieved through energy efficiency, purchasing or the generation of renewable energy.

Stormwater

The City of Melbourne is committed to achieving best practice stormwater quality protection as a way to minimise flows, capture the water resource and minimise potential impacts on the receiving waterways.

Council will seek to achieve best practice in reducing litter, suspended solids, phosphates and nitrogen in redevelopment proposals.

The City of Melbourne encourages water sensitive urban design to treat stormwater before it discharges into waterways. Maintenance needs to adjust to meet new design approach.

Council undertakes education and encourages community participation and consultation.

Sewerage system

The City of Melbourne has a target to reduce its wastewater by 20 per cent on new development sites. We are also working to reduce pollution from cotton buds, little apple stickers and other litter entering our sewerage system.

All sewerage for the City of Melbourne is treated at the Werribee Treatment Facility, with some reused on Werribee market gardens, and the rest discharged into the ocean.

The City of Melbourne is mining some of the sewer to treat and recycle this used water.

Groundwater

Groundwater beneath the City of Melbourne is generally saline and unsuitable for use.

The City of Melbourne recognises the structural and ecological value of groundwater and seeks to protect its existing quality and level.

Waterways

The Yarra River, Maribyrnong River and the Moonee Ponds Creek run through the City of Melbourne. The city lies at the bottom of the Yarra and Maribyrnong catchments.

Melbourne's waterways are in moderate-to-poor health. Better stormwater management will improve their health.

Local communities value the beauty and ecology of these waterways. The Central Business District (CBD) community gains economic benefits from a healthier Yarra River.

Section One: Table of Contents

Table of Contents

1 Introduction

These Guidelines detail how residents, businesses and the City of Melbourne can achieve the water saving and water quality targets established by *Total Watermark 2004* using water sensitive urban design (WSUD).

WSUD embraces a range of measures designed to avoid, or at least minimise, the environmental impacts of urbanisation. WSUD recognises all water streams in the urban water cycle as a resource. Rainwater (collected from the roof); stormwater (collected from all impervious run-off); potable mains water (drinking water); greywater (water from the bathroom taps, shower, laundry and kitchen); and blackwater (toilet) can all be valuable sources of water.

This document is a reference and a guide for water sensitive urban design decisions. It has been created as:
* a handbook for residents, business and councils;
* a tool to help increase awareness and appreciation of WSUD;
* a way to inform and guide urban water-management decision making processes;
* an educational document for both City of Melbourne staff and anyone involved in water management; and
* a demonstration of WSUD using innovative examples from within the City of Melbourne.

The document is divided into three sections. **Section One** examines the principles of ecologically sustainable development, with a focus on integrated water cycle management and its application to *Total Watermark 2004*. This section also presents a 'toolkit' of appropriate WSUD management strategies, including technologies and design features, to inform decision making.

The practical application of water sensitive urban design elements are united through case studies in **Section Two**. Cases studies demonstrate innovative and practical applications of water sensitive design principles. The case studies cover a range of Melbourne's demographics and stakeholders, and include different building types found within the City of Melbourne.

Section Three contains fact sheets on specific water sensitive urban design topics.

Total Watermark will be reviewed every three years. The guidelines here will be reviewed and updated accordingly, in line with any changes in the City of Melbourne's strategic direction, and to include new trends and knowledge.

2 Melbourne's urban water system

Melbourne's water is sourced from catchment in the Yarra ranges. The catchment is primarily pristine natural forests, ensuring high water quality. The water is stored in nine reservoirs, including: Thomson; Upper Yarra; O'Shannassy; Maroondah; Sugarloaf; Yan Yean; Greenvale; Silvan and Cardinia reservoirs (Figure 1). The water is treated to meet drinking water standards. The majority (90 per cent) requires minimal treatment, thanks to the pristine catchment, while the remaining 10 per cent of water is filtered. Treated water is reticulated to the urban area (Figure Two). This water is used for a range of purposes. Only a small fraction (~four per cent) is used for drinking.

Wastewater is collected by a separate reticulated network of underground pipes and directed to the Western (Werribee) and Eastern (Bangholme) treatment plants. Effluent from the Western waste water treatment plant is then discharged to Port Phillip Bay and the Eastern treatment plant to Westernport Bay. Recycling schemes are being developed to minimise effluent discharge to the bay. Melbourne Water plans to recycle 20 per cent of all effluent by 2010.

Rainfall on urban catchments (urban stormwater) is collected by a separate network of underground pipes. Most of this water is discharged directly to Port Phillip Bay, or nearby receiving waters, and is eventually discharged into the bay.

In total, there are three separate water systems operating in metropolitan Melbourne, including:
* the potable mains water supply - a piped system delivering water, treated to drinking water standard, from catchments outside the urban area;
* the sewerage system - a piped system that collects and transports domestic and industrial wastewater to treatment plants where it is discharged into Port Phillip Bay and Westernport Bay; and
* the stormwater system - incorporates various elements from waterways through to underground piped systems, that transport stormwater and other natural sources of water to Port Phillip Bay and Westernport Bay.

Melbourne's geology, primarily a basalt shelf, is not well sited for groundwater extraction. Groundwater quality and quantity are typically low in Melbourne, and this water is therefore unsuitable for extraction. *Total Watermark 2004* includes a management strategy for maintaining groundwater in the urban environment and minimising pollution.

Urban water management in Australia traditionally relies upon:
* *hydraulic infrastructure* to protect against flooding by quickly moving urban stormwater; and
* *significant piped infrastructure* to supply good quality drinking water.

The main drivers for stormwater management in Australia have been public safety, and mitigating economic impacts from flood events.

Water sensitive urban design marks a shift in thinking towards integrated resource management. Now, all water streams are considered a resource with the aim of protecting the aquatic ecosystem within the urban environment.

2.1 Water management drivers

Melbourne's population is growing, which has increased demands on potable mains water. Commitments to return water flows to our waterways for environmental benefit have placed further demands on water availability.

This increased water demand, combined with changing climatic patterns, has meant that Melbourne's water supply reliability has diminished.

At current consumption rates Melbourne may reach its supply limits within 15 years *2. Integrated water management solutions are necessary to ensure secure and reliable water supply.

Local, State and Federal Governments have made commitments to sustainable water management. The Victorian Government's White Paper, *Securing Our Water Future Together, 2004*, outlines a holistic approach for urban water management. The Victorian Government's urban planning policy for Melbourne, Melbourne 2030, is committed to water sensitive urban design. The Melbourne 2030 policy recognises stormwater quality as important to the health of Victoria's waterways, particularly Port Phillip Bay. *Total Watermark 2004* establishes the City of Melbourne's policy for integrated water management, committing the city to water conservation and quality targets.

Port Phillip Bay receives the city's stormwater and wastewater. Port Phillip Bay's aquatic ecology is inherently dependent on this receiving water. Appropriate water control and treatment is essential to maintain a healthy bay. Integrated water management, at least from an environmental perspective, is essential for Melbourne's future.

2.2 Water sensitive urban design

Water sensitive urban design (WSUD) is often confused with the concepts of 'ecologically sustainable development' and 'water cycle management'. These three concepts are different, but intrinsically linked. (See Figure 3)

WSUD benefits the natural environment through:
* conserving more water;
* improving stormwater quality, leading to better water quality in waterways, bays and catchments;
* establishing of wetlands and other 'natural' treatment alternatives that improve habitat and biodiversity; and
* reducing greenhouse gas emissions by reducing water consumption, increasing rainwater harvesting and 'natural' treatment alternatives.

WSUD benefits the urban environment in a number of ways including:
* providing natural settings for drainage, such as wetlands instead of pipes;
* the use of good water management in supporting thriving gardens and running fountains;
* educating the public on water management with visible services rather than the traditional 'invisible' pipes and drains.

As illustrated above, there is a close relationship between WSUD elements. Often, links between urban water streams develop when one element of WSUD is adopted. For example, rainwater harvesting will conserve potable mains water and reduce stormwater discharges.

There are many ways to incorporate WSUD in development projects to meet water targets.

The design strategies used in a project will depend upon:
* the location and geography of the site;
* building function and occupancy (residential, commercial, industrial);
* development or redevelopment scale;
* water use and demand (garden irrigation, industrial needs);
* water sources available, including rainfall and climate;
* on-site catchment area (roof and surface); and
* urban landscape design (architectural and landscape).

Finding the most appropriate WSUD approach for a site generally means consultations with engineers, landscape architects, architects, planners, and local community members with an appreciation of WSUD.

2.3 The City of Melbourne

Greater Melbourne covers an area of approximately 7600 km2 and supports a population of over 3.2 million people. The City of Melbourne is Victoria's capital, and is the state's business, administrative and cultural centre.

The City of Melbourne covers 36.5 km2, situated within three catchments: the Yarra River; the Maribyrnong River; and Moonee Ponds Creek. The Maribyrnong River and Moonee Ponds Creek flow into the Yarra River, which enters Port Phillip Bay at Port Melbourne.

Melbourne's average annual rainfall is approximately 650mm.

2.3.1 Demographics and characteristics

The City of Melbourne had the state's fastest growing residential population with a growth of 5.5 per cent between 1996 and 2001 *4. The city's residential population is forecast to grow from 51,000 in 1999 to 123,000 people in 2020 - and increase of 141 per cent *5.

Suburbs growing fastest include the central business district, Southbank and West Melbourne. All of these areas are home to an increasing amount of high rise apartment developments. The residential population in the City of Melbourne is young - 52 per cent are aged 18 to 34 years.

In 2005, the city has a daytime population of 567,000 including residents, employees, and visitors. Of those, 324,000 are employed in the central business district, with the majority (60 per cent) in an office environment. The daytime population is expected to increase with the overall population increase. The demand for water in the central business district will naturally increase proportionally.

2.3.2 The city's water consumption

Total Watermark 2004 offers information on water consumption in the City of Melbourne *6.

Table 1.

Summary of water consumption for the City of Melbourne

Sector	Total consumption *7	Population
Commercial (includes institutions such as hospitals and universities) Industry	17,483 ML per year (69 per cent) 760 ML per year (3 per cent)	~323,000
Residential	5,541 ML per year (22 per cent)	51,000
City of Melbourne (includes parks, gardens and reserves)	1,685 ML per year (6 per cent)	962 employees
Total (base year 1999 - 2000)	25,469 ML per year (100 per cent)	~376,000

Further breakdown on the City of Melbourne's water usage is provided on page 19 of *Total Watermark 2004* with Parks and Gardens the highest consumers at 82 per cent.

2.3.3 The city's water quality

Many water pollution and degradation issues confront the City of Melbourne's rivers and creeks, as well as Port Phillip Bay. These issues are caused by problems including: pollution from urban run-off; channelling and erosion from inappropriate land and water management; and erosion caused by loss of vegetation along creek banks.

Waterway assessment of pH, dissolved oxygen, water clarity, nutrients, E.coli and heavy metals in 1997 resulted in a rating of 'poor' for the Yarra River, Maribyrnong River and Moonee Ponds Creek.

E.coli counts in City of Melbourne rivers and creeks are generally low enough to allow secondary contact through activities like boating and fishing. Stream life, when assessed using fish numbers, is rated as 'good'. However, this probably reflects the estuarine nature of the lower Yarra that is likely to attract fish. Macro invertebrate populations and diversity in the Yarra River are poor. An assessment of vegetation and stream flow in 2004 demonstrated that the Yarra River, Maribyrnong River and Moonee Ponds Creek all rated 'poor' *8. New, long-term management approaches are needed to improve waterway health.

WSUD reduces pollution from our city's urban development, and offers solutions for continual water improvement.

2.3.4 Water sensitive urban design in highly built-up urban environments

The limited space available in the inner city has led many to believe that WSUD can't work in the city, and is only effective at large subdivision sites. However, research and experience demonstrates that WSUD elements can be designed for all different types of large and small spaces, and some form of treatment can be applied to any site.

Because the City of Melbourne contributes to problems like stormwater pollution, its responsibility in improving performance in water management is clear. WSUD elements are included in plans for Melbourne's urban regeneration and renewal.

2.3.5 Water sensitive urban design and City of Melbourne staff

Many teams at the City of Melbourne have a role in promoting WSUD, including:
* *On-ground projects*: Urban Design and Culture, Parks and Recreation, Engineering;
* *Assessment*: Planning, Building, Environmental Health;
* *Policy*: Strategic Planning, Environment, and Corporate Communications.

WSUD needs early and multi-disciplinary planning to ensure effective results.

2.4 Relevant policy and legislative background

Water sensitive urban design (WSUD) and the principles of sustainable water management are supported by the Victorian and Commonwealth Governments. Relevant policies are outlined in *Total Watermark 2004*.

3 How to approach WSUD in the City of Melbourne

5.1 Guiding Principles

The guiding principles of water sensitive urban design (WSUD) exist to help the City of Melbourne achieve integrated water cycle management.

The guiding principles include:
* Find ways to reduce potable mains water demand. This can be achieved through the use of water-efficient appliances and using alternative sources of water for appropriate purposes;
* Minimise wastewater disposal. Encouraging and helping with the installation of water-efficient appliances, and the reuse of wastewater.
* Stormwater treatment. Treating stormwater to meet water quality objectives for reuse and/or discharge to surface waters.
* Reduce the impact of urban development. Protection for catchment hydrology, particularly for aquatic habitats.
* Actions can include the prevention of urban waterway erosion, and the maintenance of natural form of watercourses.

These principles, when used in the development of the urban landscape, will help beautify the landscape, and increase the recreational opportunities in the area, as well as conserving water and improving water quality.

Integrated water cycle management involves matching available water sources with appropriate uses. For example, using drinking-quality water in irrigation and toilet flushing is a waste. Alternative water sources, like reusing water, would be better suited to the purpose, and would reduce demand for the high-quality potable mains water.

In Melbourne, there are three major water sources:

Potable mains water

Stormwater
* roof run-off (rainwater)
* 'light' greywater (only bathroom)

Wastewater
* surface run-off
* greywater (bathroom and laundry)
* blackwater (toilet and kitchen)

Smaller, localised, modular treatment technologies are favoured over centralised treatment, as they are more efficient. Centralised treatment means wastewater is first transported to treatment plants, and then, treated water is transported back to individual buildings. The transportation of water is expensive, using pumping and piping, it also uses a lot of energy.

Fit-for-purpose water use

Potable mains water should be replaced with other sources of water where appropriate. Reused water is better suited for watering gardens or toilet flushing than potable mains water.

Using this fit-for-purpose water use philosophy, and the previously mentioned guiding principles, a five-step process has been developed to help with the design, development and assessment of WSUD projects.

5.2 Five steps to water sensitive urban design

Five steps to water sensitive urban design

Step 1. Find ways to reduce water consumption.

- Water saving targets.
- Reducing the demand for water.

Step 2. Replace potable water with another water source.

- Water recycling and reuse targets.
- Available water sources.

- Rainwater and stormwater harvesting.
- Greywater Reuse.
- Blackwater Reuse.

Step 3. Treat stormwater before discharge.
- Water quality targets.
- Determine pollutant loads and stormwater treatment measures.

Step 4. Approvals design and modelling needed for WSUD
- Considering water management in the broader environment (urban design, safety, heritage, greenhouse).
- Applications to Development scales
- Modelling and design.
- Approvals.

Step 5. Undertake maintenance and evaluation
- Maintenance.
- Evaluation.

4 Step 1: Find ways to reduce water consumption.

4.1 Water saving targets

The City of Melbourne aims to achieve the following water saving targets by 2020 (compared to water use in 2000):
* Residential: 40 per cent reduction per resident.
* Commercial: 40 per cent reduction per employee.
* Council: 40 per cent reduction in total water consumption.

4.2 Reducing the demand for water

Water demand can be reduced through changing behaviour, technology and design.

In the City of Melbourne, people generally see water as plentiful and cheap. This means that water is undervalued and overused. The increasing pressure on our water resources means a change in attitude is necessary. Potable water is a valuable resource, and our everyday habits in using water should reflect this. Permanent water restrictions such as limiting gardening watering, prohibiting hosing hard surfaces, stipulating vehicle washing with buckets and permits for pool filling are now required *9.

Households in the City of Melbourne were large users per capita in 1999, with each person using an average of 296 litres per day. More recently, impressive savings have been made by residents and now the average person uses 181 litres per day.

These water saving efforts need to be maintained over the long term.

Water use can be decreased by installing water-efficient fittings (tap aerators, efficient showerheads, six/three litre dual flush toilets) and appliances (5A washing machines and 4A dishwashers). Fact Sheet One has more information about fittings and appliances.

Figure 4 shows how a typical residence in the City of Melbourne uses its water. The bathroom (27 per cent) and toilet (25 per cent) rate highest. Gardens in the City of Melbourne are generally smaller than gardens in other suburbs, but they still account for approximately 20 per cent of water use.

These results suggest that current potable mains water use could be significantly reduced by using non-potable water for toilet flushing and gardens (up to 45 per cent of total water use). Only 12 per cent of current total household use is in the kitchen where the primary use would be human consumption, including drinking and food preparation. The kitchen is the obvious place for high quality potable mains water.

It is relatively easy to reduce the demand for water. Water-efficient fittings and appliances can be easily fitted to most buildings and gardens.

5 Step 2: Replace potable water with an alternative source

5.1 Water recycling and reuse targets

The City of Melbourne's target for reducing wastewater on redevelopment sites is 20 per cent. This is based on expected savings from potable water conservation and increased use of alternative water sources.

5.2 Available water sources

Potable mains water is the primary water source for the City of Melbourne. A reduction in potable mains water use requires an increase in the use of alternative water sources.

Potential alternative water sources that are part of the urban water cycle include: roof water run-off; stormwater run-off; greywater; and blackwater. All of these water sources can be used in specific ways. Table 2 below summarises the quality of the different urban water sources, and any treatments required.

Table 2.

Summary of water quality for urban water streams

Water	Source	Quality	Treatment required
Potable mains water	Reticulated (piped) water distribution	High Quality.	None.
Roof run-off	From roof during rain, generally stored in rainwater tank.	Reasonable Quality.	Low. Sedimentation can occur inside rainwater tanks.
Stormwater run-off	Catchment run-off, including impervious areas like roads and pavements.	Moderate quality.	Reasonable treatment needed to remove litter and reduce sediment and

			nutrient loading.
'Light' greywater	Shower, bath, bathroom basins	Cleanest wastewater - low pathogens and low organic content.	Moderate treatment required to reduce pathogens and organic content.
Greywater	Light greywater, laundry water, including basin and washing machine.	Low quality - high organic loading and highly variable depending on how it was used.	High level of treatment. High organic loading and highly variable quality.
Blackwater	Kitchen, toilet and bidet water.	Lowest quality - high levels of pathogens and organics	Advanced treatment and disinfection required.

Reclaimed water (greywater and blackwater) has minimal risks if appropriately treated and used. See Section 7.4 for more information.

The piping of recycled water (reticulated reclaimed water systems) is unlikely to be retrofitted through the densely - populated Melbourne municipality. This kind of system is more appropriate for developing suburbs. Greywater reuse and reclaimed blackwater separation, otherwise known as sewer mining, are more realistic options for the City of Melbourne.

5.3 Rainwater and stormwater harvesting

Melbourne's conventional urban water cycle consists of large-scale centralised water supply and disposal system as shown in Figure 5. Water is collected from a large catchment area, treated and delivered via a pipe network to the customer. After use, the wastewater flows through a second set of pipes, the sewer, to Melbourne's sewerage treatment plants. The treated water is then discarded into Port Phillip Bay.

Stormwater provides an alternative water source for use within the City of Melbourne as shown in Figure Five. Stormwater can be captured and used for toilet flushing, garden irrigation, the washing machine and the hot water system.

Water storage tanks can be incorporated into new or existing buildings and open space areas so that they do not impact on the aesthetics of the building or streetscape. Tanks should be the right size for the job. Fact Sheets with information on tank sizing, installations and approvals are now available.

Stormwater can also be captured and treated from ground surfaces such as roads, plazas and carparks. Section 6.2 has more information on stormwater capturing.

The capture and use of rainwater and stormwater on-site is an environmentally preferable source of alternative water as this method generally does away with the need for piping or pumping. Fewer resources are needed and greenhouse gas emissions are reduced.

5.4 Greywater Reuse

Residential and commercial greywater (water from the laundry, bathroom taps and shower) along with industrial greywater (slightly polluted water reused in manufacturing) can save significant quantities of potable water, and reduce the need for treatment of wastewater. Typically, treatment of greywater is required, and the treated water used for toilet flushing, garden irrigation and clothes washing.

Greywater contains contaminants and is not fit for human consumption. Contaminants include: low levels of bacteria; faecal matter; organic matter; micro-organisms; salts and detergents. All of these contaminants can contribute to colour and odour. Care must be taken to limit human exposure to greywater. Collection, treatment and reuse of greywater should ideally use a closed system, minimising health risks. Simple caution should be exercised to manage health risks including *11:
* no cross-connections between greywater and drinking water systems;
* excess greywater is directed to the sewer; and
* greywater reuse is contained within the system, limiting exposure.

Correct management and appropriate use ensure greywater is safe. Further advice is available from Victoria EPA and the Victorian Department of Human Services.

Greywater diversion

A simple way to reuse greywater is to divert it to the garden for irrigation. Greywater diverted to the garden can be used immediately, with little treatment required. A diverter could redirect greywater from the washing machine to:
* an underground (subsurface) garden irrigation, protecting against human contact; or
* a storage area. Typically, disinfection would be required for this option.

Figure 8 shows a typical greywater diversion system. The greywater is redirected through a diverter valve. This system can be retrofitted to existing buildings, usually near the laundry. Water is then fed to the garden via an underground (subsurface) irrigation system. To reduce clogging and root ingress, chlorination or emitters impregnated with biocides and herbicides can be used.

Currently there is no Victorian legislation specific to the use of untreated greywater. Simple greywater diversion systems do not require EPA or Council approval *12. All plumbing should completed by a licensed plumber in accordance with Australian Standards (AS3500.1.2 *Water Supply: Acceptable Solutions*).

The greywater diversion system illustrated here minimises public health risks. This system has no provision for storage, and because the irrigation is subsurface, human contact is limited.

Greywater should not be used to irrigate vegetable gardens and should not be used during wet weather. The Department of Human Services does not recommend the use of untreated greywater within the household *13.

Temporary greywater storage

Greywater can be temporarily stored and reused on site. Storage of up to 24 hours without treatment is acceptable, before greywater must be discarded to sewer. Storing untreated greywater for more than 24 hours is hazardous, as it may lead to microbial growth, odours and septic water. If greywater is to be stored for more than 24 hours, treatment is required.

Greywater treatment

'Light' greywater is wastewater from the shower, bath and basin in bathrooms, and requires the least amount of treatment. An effective light greywater treatment system requires:

* underground tanks;
* pumps;
* an on-site disposal system; and
* the residents' active participation and involvement.

A suggested greywater treatment system is shown in Figure 9. The system as it would be used in a typical building is shown in Figure Ten.

For a multi-storey residential development (Figure Ten), a dedicated collection system is needed to collect greywater. A separate system is needed to treat water for reuse. A header tank is usually installed to prevent fluctuations in water supply.

Collected greywater may be used in a number of ways. Greywater water may be treated, depending upon how it is reused. The Environment Protection Agency Victoria (EPA) has prepared guidelines for the use of reclaimed water. The water quality objectives for greywater are summarised in Table 3.

No farming is done in the City of Melbourne, so the EPA's specifications for agricultural use are not included in this table. The pH of all waters should be between six and nine[h2].

The EPA Victoria's publication 464.2 (2003) *Use of Reclaimed Water* has more detailed information.

Table 3.

Water quality objectives for reclaimed water treatment (Victoria EPA, publication 464.2, Table 1)

Class	Water quality objectives	Ranges of uses, including lower class uses
A	<10 E.coli org/100ml <10 mg/L BOD <5 mg/L SS Turbidity < 2 NTU Disinfection	Urban - uncontrolled public access. Used in toilet flushing, irrigation. Industrial - used in open systems. There is a potential for worker exposure.
B	<10 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Industrial - used as wash down water, for example.
C	<1000 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Urban - controlled public access. Used - controlled public access. Used in subsurface irrigation or irrigation of areas where there is no public access.

Technologies available

Options for the treatment of greywater include:
* subsurface flow wetlands (fact sheet 4a);
* suspended growth systems, including activated sludge systems (fact sheet 5a);
* fixed growth systems, including trickle filters, rotating biological contactors (RBC) (fact sheet 5b);
* recirculating media filters (fixed film bioreactor) (fact sheet 5c);
* sand and depth filtration (fact sheet 5d);
* membrane filtration including micro, ultra, nano filtration and reverse osmosis (fact sheet 5e); and
* membrane bioreactor (fact sheet 5a).

More options are available. The list above is a guide to the most common and practical treatment systems available in Melbourne. Finding the right technology means considering:
* how the water will be used;
* the quality and quantity of water before treatment;
* the quality and quantity of water needed following treatment;
* available space;
* cost;
* environmental objectives, including the City of Melbourne's *Zero Net Emissions by 2020* strategy;
* climate; and
* operation and maintenance.

With so many variables, choosing the right treatment technology can only be done on a case-by-case basis. If specific pollutants are of concern, table 4 below should help. It lists the main pollutants, and methods of removal. For more information, refer to the fact sheets indicated below.

Table 4.

Overview of treatment technologies and their pollutant removal abilities *14

	Suspended solids (TSS)	Biodegradable organics (BOD removal)	Nutrients: nitrogen	Nutrients: phosphorous *15	Salts	Pathogens	Fact Sheet
Subsurface flow wetland	Yes	Yes	Yes	Yes	No	Good *16	4a

Biological processes - suspended growth systems	Yes	Yes	Yes	Limited	No	Limited	5a
Biological processes - fixed growth	Yes	Yes	Yes	Limited	No	Limited	5b
Recirculating media filter	Yes	Yes	Yes	Limited	No	Limited	5c
Depth Filtration	Yes	Function of size	Limited	Limited	No	Limited	5d
Membrane filtration *17	Yes	Function of size	Function of size	Function of size	Reverse osmosis only	Function of size	5e
Disinfection	No	No	No	No	No	Yes	5f

The scale of the site will affect your choice of technology. For single households, simple greywater reuse systems are preferable. The maintenance and management of larger systems make them more appropriate for larger scale sites.

Table 5.

Greywater treatment technologies for different scales

Scale	**Treatment technologies**

Small Household	Greywater diversion Temporary storage Subsurface flow wetland Disinfection
Medium High rise residential development Mixed use urban development Residential urban development/redevelopment	Subsurface flow wetland Biological processes - suspended growth systems Biological processes - fixed growth systems Recirculating media filter Depth filtration Disinfection
Large Commercial development Industrial development	Biological processes - suspended growth systems Biological processes - fixed growth systems Depth filtration Membrane filtration Disinfection

Greywater treatment usually involves a combination of treatment technologies. Figure 11 below shows the key components of one greywater treatment system.

Mesh screen: traps larger objects, removing them from the process.

Sedimentation Tank: works as a surge tank (to regulate 'in' flow), and helps remove larger-sized pollutants through sedimentation.

Treatment: reduces and/or dissolves organic matter.

Clarifier: stabilises flow and removes excess biomass by sedimentation.

Filtration: (not shown) improves water quality, dependent on health regulations. Sand or membrane may be used as a filter.

Disinfection: kills micro-organisms including pathogens and bacteria.

Storage tank: a reservoir to cover occasional increases in demand

Greywater should be disinfected to minimise public health risks and prevent 'bio-fouling' in the system. Organic material, if not removed, can cause greywater to become anaerobic and give off odours. Ultraviolet (UV) disinfection is the best option, but chlorination and ozonisation can also be considered. Fact Sheet 16 has more information on disinfection.

5.5 Blackwater Reuse

The City of Melbourne has an extensive sewerage network, designed to transport water to large scale treatment plants. There is potential to use this water as a resource, rather than transport it away. Blackwater can be extracted from the sewerage system, treated and reused. This 'reclaimed water' could be used in irrigation and toilet flushing.

Treatment is necessary before blackwater is reused. High pathogen levels in blackwater mean disinfection is also necessary. Because the treatment of blackwater can be energy intensive, it is a good idea to consider Ecologically Sustainable Development objectives when choosing the right treatment option for your site. The City of Melbourne's *Zero Net Emissions* by 2020 provides helpful guidelines on energy efficiency.

Smaller scale systems that extract and treat water as needed are preferred for Melbourne. Small treatment plants produce water quality and quantity as required, avoiding the need for storage.

Sewer mining

Typical urban sewage is mostly water, with less than five per cent solids *18. Treatment and disinfection are essential for reuse. Obviously, untreated or disinfected sewage has high pathogen levels.

Sewer mining systems usually combine technologies to extract and treat sewage. These can be purchased as 'package treatment plants'.

Sewer mining removes water from sewage (blackwater). The remaining solids are immediately returned to the sewer for treatment at a sewage treatment plant. The water is then further treated, usually to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS) *19. The disinfected, reclaimed water is then ready for reuse. Fact Sheet 5f has more information about disinfected blackwater.

Sewer mining has been successful in Melbourne, with reclaimed water used for irrigation in Albert Park *20, the Flemington Racecourse and the Domain. Council House Two (CH2), the City of Melbourne's new staff building, now under construction, includes a blackwater treatment system, situated in the base of the building, with reclaimed water to be used for toilet flushing.

The 60L - Green Building in Carlton is currently commissioning a biological process to reuse blackwater onsite for toilet flushing *21.

Sewer flow rates and quality

Effective sewer mining matches supply with demand. Sewer flow peaks in the morning and evening, in line with people's every day activities. As a blackwater collection (sewer) system increases in size, variation in flow is reduced. The supply of a reliable quantity of water depends upon the available source and upstream network.

Smaller collection systems have greater sensitivity to flow variation. The continuous sewer extraction potential for smaller sewer mining systems is therefore limited. A surge tank, used for on-site storage, can help meet demands for more water. This means increasing the required footprint for the system. Exact configurations will depend on the collection system nature and extraction point.

The advantage of a smaller upstream collection network is a more certainty of supply quality. Potentially hazardous consumers such as industrial and other trade waste customers can be avoided by carefully selecting sewer extraction points.

Water quality, sewer extraction and required treatment

Water extracted from sewers is of variable quality and is highly contaminated. The extracted water has similar characteristics to domestic wastewater, needing treatment before reuse. Domestic wastewater typically contains high total suspended solids (120-370 mg/L), high biochemical oxygen demand (BOD) (120-380 mg/L), high levels of micro-organisms (faecal coliform bacteria 105-107), high nutrients total nitrogen (20-705 mg/L) and total phosphorous (4 -12 mg/L) *22.

How the water is used will dictate the quality required. Typically, higher water quality is required for water used for toilet flushing and irrigation where public access can't be controlled.

EPA Victoria's guidelines for the use of reclaimed water (publication 464.2) stipulates reclaimed water quality.

Blackwater treatment systems include sewer extraction, screening and treatment (refer to Figure 13). Pumping systems are designed to minimise solids extraction, reducing treatment costs. Putting the extraction point closest to the surface within the sewer will also reduce solids intake. Some systems use floating intakes to ensure minimal solids are withdrawn and/or a macerator pump to break up solids from the blackwater.

A primary separation process usually follows extraction to remove any remaining solids. Screening is the most common physical separation process employed, with the screened solids returned immediately to the sewer. Wastewater can be used to continually clean the screen, thereby preventing clogging. Variations on pre-treatment include hydro-cyclone separators, sedimentation, enhanced sedimentation and dissolved air flotation (DAF) devices.

Technologies available

Sewer mining technologies are similar to those used for greywater systems. The main difference is the in-flow wastewater quality. Sewer mining treatment must reduce the high organic and micro-organism concentrations and control pathogen levels. Technology design parameters will accommodate changes in water characteristics and pollutant loading. Sewer mining treatment technologies include:

* subsurface flow wetlands (fact sheet 4a);
* suspended growth systems, including activated sludge systems (fact sheet 5a);
* fixed growth systems, including trickle filters (fact sheet 5b);
* recirculating media filters (fixed film bioreactor) (fact sheet 5c);
* sand and depth filtration (fact sheet 5d);
* membrane filtration (micro, ultra, nano filtration and reverse osmosis) (fact sheet 5e); and
* membrane bioreactor (fact sheet 5a).

This technology list is indicative only. New technologies are expected to become commercially viable as competition increases in the water market.

Technology selection should be considered on a case-by-case basis with key considerations similar to greywater treatment. How reclaimed water is used will determine the water quality needed. Refer to EPA Victoria's guidelines for reclaimed water (publication 464.2) for more information. Table 6 offers a basic breakdown of requirements.

The size of the site can determine the technology used, as per Table 6 below. For single households, greywater reuse is a better option. Blackwater treatment and reuse is more appropriate for larger scale applications.

Table 6.

Suggested blackwater treatment technology for different scales

Scale	Treatment Technologies
Small Household	Should be sent to centralised sewerage treament plant via sewer.
Medium High rise residential development Mixed-used urban development Residential urban development/redevelopment	Biological processes - suspended growth systems Biological processes - fixed growth systems Depth filtration Membrane filtration Recirculating media filter Disinfection
Large Commercial development Industrial development	Biological processes - suspended growth systems Biological processes - fixed growth systems Depth filtration Membrane filtration Disinfection

After treatment, most systems require disinfection to control the high concentration of pathogens. Fact sheet 5f lists appropriate disinfection options. Disinfection is not required after reverse osmosis. The membrane's pore size reduces pathogen concentration by physical removal.

In selecting technology, broader ecologically sustainable development objectives, particularly greenhouse gas emissions, should be considered. The City of Melbourne's *Total Watermark* is committed to zero net emissions by 2020 *23. Emissions from water reuse technologies (including the use of energy for pumping, treatment, and biological processes) must be neutralised. Energy efficiency and the generation or trade of renewable energy can help us achieve our goal.

Reclaimed water use in buildings

Sewer mining is well suited to commercial high-rise developments, where other potential water sources, like rainwater harvesting, are limited due to typical roof designs. Greywater production is limited by a lack of showers in commercial buildings. In commercial high-rise developments, the sewer is a consistent water resource, making sewer mining the best option for water reuse and conservation.

In commercial buildings, most water is used in toilet flushing. High quality potable water is unnecessary for this purpose, while treated blackwater is suitable, providing a good match between use and supply. A sewer mining plumbing schematic for a high rise commercial development is shown in Figure 14.

Sewer mining systems require a dedicated third pipe to deliver reclaimed water to toilets. Space for the third pipe must be included in the construction of the building. Treatment technologies are available in 'package plants' that can be situated in the basement.

Package treatment systems are ideal for decentralised treatment. Because the operation can increase treatment and extraction rates according to demand, there is little or no on-site storage. The reduction in storage requirements make these systems good for urban retrofitting. Sewer mining systems have been used in Albert Park, and are planned for City of Melbourne's CH2 building, and for Flemington Racecourse. Common 'package' treatment plants combine the technologies listed in Table 6 and are available from proprietary companies. They are often sized to fit inside a shipping container.

6 Step 3: Treating stormwater before discharge into waterways

6.1 Water quality targets

Stormwater quality - to protect Port Phillip Bay's ecology, stormwater pollutant and nutrient loading should be minimised. Best practice pollutant load reduction targets are consistent with the Urban Stormwater Best Practice Environmental Management objectives established by the Victorian Stormwater Committee (1999). These are:
* total suspended solids - 80 per cent reduction in the average annual load from that typically generated from an urban catchment; and
* total phosphorous and total nitrogen - 45 per cent reduction in the average annual load from that typically generated from an urban catchment.
* litter - 70 per cent reduction in litter entering stormwater from the site.

The City of Melbourne's Drainage Plan 2004-09 outlines stormwater quality targets for the municipality. The plan also commits to the application of water sensitive urban design (WSUD) *24. Clear guidance and commitment to WSUD is provided within the plan. The City of Melbourne's adoption of WSUD complements and enhances the Drainage Plan, and strategies for peak-flow management are consistent with WSUD elements.

The City of Melbourne's water management policies have been developed to achieve sustainable water management targets. The targets are measurable indicators of water management, and may need revising if experience proves they are not effective.

Actions are:

1. Prevent soil sediments, nutrients, gravel and pollutants entering our stormwater system and waterways.
a. Set a stormwater quality baseline and targets using typical urban loads (sediments, suspended solids, phosphates and nitrogen) by 2004.
b. By 2005, 95 per cent of construction and demolition applications to consider whether a Construction Management Plan (addressing stormwater protection) is required.
c. A five per cent increase in permeable surface area for Council land from 2004.
d. Work with relevant authorities to identify priority sites for revegetating banks/verges of waterways to slow water velocity and prevent erosion by 2005. Revegetate 50 per cent of these by 2012.
e. Ten high impact industrial and commercial businesses to undertake comprehensive stormwater protection program by 2007.

2. Prevent litter from entering the stormwater system and watercourse to improve urban aesthetics and prevent damage to aquatic flora and fauna.
a. Set comprehensive baseline data with breakdown of litter by 2004.
b. A 20 per cent increase in gross litter traps by 2007.
c. A 10 per cent reduction in litter by 2007.
d. A 10 per cent reduction in cigarette butts by 2007.
e. A five per cent increase in number of people educated and/or involved in water quality activities by 2010.

3. Minimise pesticide and herbicide use by encouraging sustainable landscaping practices.
a. Establish baseline data for herbicides and pesticides used by the City of Melbourne by 2006.
b. Chemical Management Plans to be prepared for the City of Melbourne's Parks and Gardens by 2005.
c. The City of Melbourne to identify opportunities for biological control techniques, and trial one, by 2007.

4. Promote greywater and rainwater use to save water and reduce stormwater run-off.
a. A 15 per cent increase in greywater/rainwater systems being used in municipality by 2007.
b. Undertake two demonstration rooftop garden programs by 2007.

c. Incorporate sustainable water design practices in 90 per cent of City of Melbourne urban design projects by 2005.
d. Three parks to incorporate WSUD projects by 2007.
e. Two demonstrations of road layout to be constructed with application of WSUD by 2010.
f. One City of Melbourne swimming pool to implement rainwater harvesting by 2007.
g. City of Melbourne water recycling projects to have neutral or reduced level of greenhouse gas emissions.

6.2 Determine Pollutant Loads and Stormwater treatment measures

Best-practice urban stormwater management aims to meet multiple objectives including:
* providing flood conveyance to reduce velocities;
* protecting downstream aquatic ecosystems;
* removing contaminants; and
* promoting WSUD elements as part of the urban form.

Stormwater systems provide infrastructure to avoid nuisance flooding and flood damage to public and private property. Stormwater systems also provide on-site stormwater retention and detention, protecting downstream aquatic ecosystems from increased flow volumes and rates.

Urbanisation produces many contaminants. During storms or heavy rainfall, these contaminants can be washed or blown into waterways, affecting their health. Best practice stormwater management provides for treatment of run-off. Treatment removes water- borne contaminants, protecting the environmental, social and economic values of receiving waterways.

Pollutants of many types and sizes are carried in stormwater, and no single treatment measure can effectively treat them all. The design of most stormwater pollutant removal processes, mean that only some pollutants can be targeted. A combination of treatments is required to remove all, or most, stormwater pollutants.

A series of treatment measures that collectively address all stormwater pollutants is called a 'treatment train'. The selection and order of treatments is vital to the effectiveness of a treatment train. Coarser pollutants generally require removal so that treatments that target fine pollutants can operate. The proximity of a treatment to its source is another factor to consider, as is the distribution of treatments throughout a catchment.

The individual stormwater treatment measures outlined in Table Seven can be used together to treat pollutants generated in an urban area.

Table 7.

Site conditions and benefits of stormwater treatments

Treatment Measure	**Potential benefits**	**Suitable site conditions**	**Unsuitable conditions**
Gross pollutant traps (Fact Sheet 3d)	Reduces litter and debris. Can reduce sediment. Pretreatment for other measures.	Conventional drainage systems	Sites larger than 100 ha Natural channels
Sediment basins (Fact Sheet 3c)	Course sediment capture. Temporary installation. Pretreatment for other measures.	Need available land area.	Proximity to airports
Rainwater tank (Fact Sheet 2a)	Storage for reuse. Sediment removal in tank. Frequent flood retardation.	Proximity to roof Suitable site for gravity feed Incorporate to urban design	Non-roof run-off treatment
Vegetated swales (Fact Sheet 3a)	Medium and fine particulate removal. Streetscape amenity. Passive irrigation.	Mild slopes (< four per cent)	Steep slopes
Buffer strips (Fact Sheet 3a)	Pretreatment of run-off for sediment removal. Streetscape amenity.	Flat terrain	Steep terrain
Bioretention system (Fact Sheet 3b)	Fine and soluble pollutants removal. Streetscape amenity. Frequent flood retardation.	Flat terrain	Steep terrain High groundwater table

Ponds (Fact Sheet 4c)	Storage for reuse. Fine sediment settling. Flood retardation. Community and wildlife asset.	Steep terrain with confined valleys	Proximity to airports, landfill
Wetlands (Fact Sheet 4a and 4b)	Community asset. Medium to fine particulate and some soluble pollutant removal. Flood retardation. Storage for reuse. Wildlife habitat.	Flat terrain	Steep terrain High groundwater table Acid sulphate soils
Retarding basins (Fact Sheet 3c)	Flood retardation. Community asset.	Available space	Limited available space Very flat terrain

Site conditions and the characteristics of the target pollutant(s) will obviously influence treatment measure selection. Climate conditions are another important factor to consider, influencing the hydrologic design. Climate can also play a major part in the success (or failure) of pollutant removal. An overriding management objective can help determine what treatment process is likely to be feasible. Figure 15 shows the relationship between management issues, likely pollutant sizes and treatment processes.

Figure 16 shows the inter-relationship between stormwater pollutant particle size, and the suitable types of treatment measures that can be used for each size. This also takes into account their water flow capacity (hydraulic loading).

Stormwater treatments that target the removal of gross pollutants and course sediments, (including gross pollutant traps and sediment basins), can operate under high hydraulic loading. This means they can treat high flow rates for a given size of unit. This is reflected by the process of pollutant removal used. Sedimentation, or a rapid process of physical screening, are both suitable treatments for gross and/or coarse pollutants. See Figure 15 for more details.

Treatments for smaller pollutant particles (including nutrients and metals) can include sedimentation, bio-film adsorption and biological transformation. These treatments use vegetation as the filtering surface area, and to spread and reduce flow velocities. Vegetation enhances sedimentation and providing a substrate for biofilm growth and biological uptake of soluble pollutants. Grass swales, vegetated buffer strips, surface wetlands and infiltration systems take longer than gross pollutant traps to remove pollutants. Consequently, the hydraulic loading on these treatment measures is small relative to the gross pollutant removal measures. A larger proportion of land is required for treatment of smaller pollutant particles.

7 Step 4: Approvals, design and modelling needed for WSUD

7.1 Considering water sensitive urban design in the broader environment

Best planning practices

Planning for water sensitive urban design (WSUD) elements should be part of an urban development from the very beginning. Land-use planning techniques and concepts should be applied to development layouts to find all opportunities for the inclusion of WSUD elements. A functional water treatment facility can become a water feature, enhancing the aesthetic, amenity and recreation opportunities of an area, as well as protecting its environmental values.

Open space layout

The integration of open space with conservation corridors, stormwater management systems and recreational facilities is a fundamental objective of WSUD. Open space areas could include stormwater conveyance and treatment systems as landscape features. When locating open space areas consider:
* the alignment of open spaces along natural drainage lines;
* the protection/enhancement areas of containing natural water features and other environmental values by locating them within open space such as the Yarra River and Victoria Harbour; and
* the use of open space to link public and private areas and community activity nodes, especially in new developments.

Road layouts and streetscaping

Most impervious hard surfaces in urban developments are roads. Road designs can change the way water is transported through an area. Roads also generate water-borne stormwater contaminants (including fine sediments, metals and hydrocarbons) that can damage receiving waterway health. Road alignments and

streetscapes should be carefully planned. Appropriate WSUD drainage elements include:
* bioretention systems; and
* vegetated swales that collect, attenuate, convey and treat run-off before discharge to receiving waterways.

Roads and streetscapes are continually upgraded in the City of Melbourne. Opportunities exist for incorporating stormwater elements in roadways by diverting flow roads to a treatment system. Traditional road features (medians, traffic calming bays, street trees and car parking nodes) would need to be lowered below road-level to collect run-off from the road. Other features such as kerb and channel could be replaced with grass swales.

Street trees can be retrofitted into stormwater treatment bioretention planter boxes. Stormwater, diverted into the planter box, is filtered through a sandy loam prior to discharge to the stormwater systems. Figure 17 shows a series of images of street planter boxes which divert road run-off to a sandy-loam filter media.

Medians and traffic calming bays can be retrofitted as bioretention systems, like in Cremorne Street, Richmond.

The vegetated area on the left of Figure 18 could be retrofitted to include a stormwater entrance. Water treated by the system, and excess stormwater, is diverted back to the side entry pit.

Lot layouts

The City of Melbourne is, of course, highly urbanised, with little development of new lots in the municipality. Nevertheless, it is useful to consider the integration of open space with WSUD elements.

WSUD promotes the use of smaller, compact housing lots, adjacent to open spaces for community access. WSUD elements, such as natural and landscaped water features, could form the local stormwater drainage system. Natural landscape features, including significant remnant vegetation and natural waterways should be incorporated within open space wherever possible. Housing lots should be configured around the open space, giving views and access to the open space. Connecting homes to open space means smaller lots are possible - less lawn and garden area is needed on each lot when open space is readily accessible. Lots with direct access to open space and water features would most likely have higher values than conventional lots.

This approach is useful to evaluate new developments and their relationship to natural drainage lines.

7.2 Application to development scales

Five Steps to WSUD helps users apply a demand-management and fit-for-purpose approach to water management.

Below is a summary of different WSUD applications.

Low density residential

Expected potable mains water savings for typical residential households with WSUD elements are presented in Figure 19. A combination of demand management, using treated wastewater or greywater for toilet flushing and garden watering, and rainwater in hot water systems offers the biggest saving. In this example, hot water demand is assumed to be about 40 per cent of indoor water use. These preliminary estimates show the potential hierarchy of water savings for the average household.

The greatest potable mains water saving (80 per cent) could be achieved by combining demand management (Option One), using rainwater for hot water (Option Two) and using reclaimed water or greywater for toilet flushing and garden irrigation (Option Three).

In the absence of reclaimed water (sewer mining or a 'third pipe' reticulated treated wastewater system) or greywater systems, the combination of demand management (Option One) and rainwater used for toilet flushing and garden watering (Option Four) provides a 40 per cent saving.

Development scale, layout, proximity to wastewater treatment facilities and local climate should all be taken into consideration in setting individual targets for water demand reduction.

High rise residential development

High rise urban development is typical of present and future residential growth within the City of Melbourne. In high rises, residential water demand is similar to a typical household with the exclusion of garden irrigation. Stormwater capture from the roof is limited as only a small surface area is available to capture water for a large number of residents. A combination of Options One (demand management) and reclaimed or greywater for toilet use (Option Three) is recommended.

Low-density households can combine water efficiencies, rainwater harvesting and in some cases greywater technologies to reduce water consumption.

Commercial office development

Typically in office buildings, water usage is dominated by toilet flushing. Relatively small demand exists for drinking water and garden irrigation. There is minimal showering in these buildings, so little greywater is produced on-site. A combination of demand management (Option One) and reclaimed water for toilet flushing (variation of Option Three involving sewer mining) is recommended.

Events and institutions development

The commercial sector includes offices, schools, universities, hospitals, markets and event venues like the Melbourne Cricket Ground, Flemington Racecourse and the Melbourne Museum.

These venues can reduce water demand through efficient toilets, showers and appliances (Option One). Buildings with large catchment areas (a large roof area, for example) can harvest rainwater for toilet flushing (Option Two). These types of developments often have large gardens so rainwater harvesting for irrigation is also possible (Option Three). Stormwater could also be harvested from large car park areas.

Mixed-use urban development

Mixed-use developments in the City of Melbourne usually combine residential with commercial uses. The building height, density, landscape area and use will determine the WSUD strategy. The ratio of stormwater roof run-off to the number of residents will determine the feasibility of rainwater harvesting. Often, greywater can be collected as an alternative water source for toilet flushing and garden irrigation (Option Three). A combination of Option One and Option Three is recommended.

Industrial development

Industrial water uses are generally determined by the type of industry and the site. Water uses range from cooling water for industrial equipment to very high purity water used by technology companies. Industry should demonstrate best water management practice and use fit-for-purpose water. Multiple uses of water within a manufacturing site are possible, as is the use of reclaimed water for process cooling, and the harvesting of stormwater for on-site use.

The City of Melbourne is home to many varied industries, with hugely different water uses. Approaches to WSUD for industry are best considered on a case-by-case basis.

7.3 Modelling of design options

Urban stormwater quality improvement systems are mostly driven by either storms or dry weather. Melbourne is famous for unpredictable and sometimes extreme weather, and this factor makes the management of urban stormwater an unpredictable business. The performance of an urban stormwater quality improvement strategy is not measured by an individual storm event, but through the impact of a continuous period of typical climatic conditions. Monitoring water quality after only a small number of storm events is not an effective measurement of system performance.

The success of a stormwater treatment strategy will often be measured by estimating mean annual pollutant loads exported from a catchment. Modelling using well-established computer models of urban stormwater management systems is a recognised method for determining their long-term performance. Modelling involves using historical or synthesized long-term rainfall data and algorithms that can simulate the performance of stormwater treatment measures. Modelling can determine the success of a particular stormwater pollution control method.

The performance of a proposed stormwater quality management strategy is usually benchmarked against conventional drainage design. Modelling techniques allow this comparison by simulating the likely performances of the development for the two scenarios of the urban stormwater management systems based on a conventional and a WSUD approach.

The Cooperative Research Centre for Catchment Hydrology has developed stormwater management evaluation software. Their Model for Urban Stormwater

Improvement Conceptualisation *25, or MUSIC software is a planning and decision support system. The software packages the most current knowledge of the performance of stormwater treatment measures into an easily used tool. MUSIC is designed to operate at a range of temporal and spatial scales, so it is suitable for modelling stormwater quality treatment systems for individual lots up to regional scales.

Importantly, MUSIC allows a first estimate on expected pollutant load from catchments following development in the absence of stormwater treatment initiatives, setting a baseline. From this figure, alternative stormwater treatment strategies can be compared, for compliance to state and local government stormwater quality objectives. Figure 20 shows an example of a MUSIC model, demonstrating stormwater treatments for a typical residential development.

There are other computer models that allow a user to model the performance of a group of treatments or an individual treatment measure. Phillips and Thompson (2002) describe an application of XP-AQUALM in the development of a management strategy for drainage and stormwater, as part of a water cycle management strategy for Sydney's Olympic Games Village. Currently, MUSIC and XP-AQUALM are the two most widely-used tools for modelling urban stormwater quality improvement systems.

The application of computer models to predict the performance of individual or a group of stormwater treatment measures is not a simple exercise and requires a level of modelling expertise.

7.4 Approvals

Stormwater

Stormwater treatment works can take various forms in the urban environment. Some treatment works will involve infrastructure upgrades, streetscape layout changes, piping reconfigurations, siting of storage tanks, the laying of different paving and other such variations. Planning approval will often be necessary.

If work changes land use, or impacts the local environment, an applications for planning approval is essential. A meeting with the statutory planning department of the City of Melbourne is recommended to determine whether a permit is needed for your proposed work. All applications and approvals should be processed before work begins.

The statutory planning department can also give advice on what to include in submissions, and the likely timing of approvals.

Heritage provisions apply to most of the City of Melbourne and therefore a heritage permit may also need to be obtained.

Greywater

Simple greywater diversion systems do not require approval.

EPA Victoria approval is required for greywater treatment systems that treat more than 5,000 litres a day, and the EPA should be contacted directly to arrange this. The water quality in greywater treatment systems must be similar to the EPA Victoria's guidelines for reclaimed water. Water should be treated to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS) *26 for toilet flushing and unrestricted irrigation. Class B (100 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) and Class C (1000 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) quality water is appropriate for restricted access irrigation.

For systems treating less than 5,000 litres a day, EPA Victoria has a list of approved greywater treatment systems. The City of Melbourne can issue permits for EPA approved systems. Approved greywater devices are listed on EPA Victoria's website (www.epa.vic.gov.au) and EPA publication 812 *Reuse Options for Household Wastewater* has more information about greywater use.

EPA approval is not required for closed systems, where no water is released into the environment.

All installations must conform to Australian Standards, with reference to *AS3500.1.2 Water Supply: Acceptable Solutions*, wastewater treatment *(AS1546)* and wastewater effluent management *(AS1547)*, as well as plumbing requirements. A licensed plumber is required to install the system. Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for more information.

The Department of Human Services also has guidelines for greywater reuse. Visit their website, www.health.vic.gov.au/environment/ for more details.

Blackwater

EPA Victoria approval is required for water treatment systems that treat more than 5,000 litres a day and should be contacted directly. EPA Victoria has guidelines for the *Use of Reclaimed Water* from sewage treatment plants (refer to publication 464.2). These guidelines can be used to determine requirements for large-scale water treatment.

Water quality is expected to be similar to the EPA Victoria's guidelines for reclaimed water, requiring water to be treated to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS) for toilet flushing and unrestricted irrigation. Class B (100 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) and class C (1000 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) quality water is appropriate for restricted access irrigation *27.

EPA Victoria sees blackwater systems treating less than 5,000 litres a day as septic systems. EPA Victoria has guidelines for on-site wastewater treatment (refer to the *Code of Practice - septic tanks*; publication 451). The City of Melbourne has the approval authority for such systems and can issue permits. The approved treatments are listed on the EPA Victoria's website, www.epa.vic.gov.au

All installations must conform to Australian Standards, with reference to AS3500.1.2 Water Supply: Acceptable Solutions, wastewater treatment *(AS1546)* and wastewater effluent management (AS1547), and plumbing requirements. A licensed plumber is required to install the system. Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for additional information.

The Department of Human Services has responsibility for approving large scale reclaimed water systems where there is potential for 'high exposure' from Class A water applications. High exposures examples include:
* the use of reclaimed water for toilet flushing in a residential building; and
* irrigating an unrestricted area.

The department should be contacted for approval.
www.health.vic.gov.au/environment/.

All

In commercial properties, water recycling projects designed to discharge less than 90 per cent of water consumed can have their Sewage Discharge Factor lessened on completion of the project. This can be done by contacting the water retailer (City West Water or South East Water). If it is a trade waste site this can be done by a trade waste officer through a standard water declaration form, if not through account enquiries.

Groundwater

Melbourne's geology, primarily a basalt shelf, is not well sited to groundwater extraction, with the water quality and quantity being typically low. Groundwater extraction is therefore unfeasible, and *Total Watermark 2004* presents a management strategy to maintain groundwater in the urban environment and minimise pollution. In all cases, changes to the built or natural environment should protect or enhance both groundwater quality and quantity. The management principles for groundwater are:

* groundwater quantity - over the long term, there should be no net change in the water quantity;
* groundwater quality - water injected should be of equivalent or greater quality to the receiving groundwater.

The beneficial user of groundwater has a responsibility to ensure groundwater is appropriately managed.

8 Step 5: Undertaking maintenance and evaluation

8.1 Maintenance

Stormwater

Limited cost data is available for the operation and maintenance of water sensitive urban (WSUD) design stormwater management. Well-designed and constructed systems should not incur costs above those required to maintain conventional stormwater infrastructure and associated public open space. Poor construction and/or damage during development can result in increased maintenance costs for both WSUD elements and traditional systems.

The maintenance of vegetated swales and bioretention systems usually means conducting weed control and vegetation pruning. Lloyd et al. (2002) *28 reported maintenance costs data over a seven-year period of a vegetated swale system at a residential estate in Melbourne. Following an initial high-maintenance cost during the establishment of the vegetation, the maintenance cost fell from around $9 per square metre to $1.50 per square metre - less than it costs to mow a lawn of the same size. (Figure A5 in Lloyd et al., 2002).

The annual maintenance costs of constructed wetland systems have been estimated at $14,000 per hectare by Lloyd et al. (2002) for wetlands in Melbourne.

Greywater

Each greywater treatment has its own maintenance requirements. Manufacturers and suppliers can provide relevant maintenance regimes. For example, a subsurface wetland requires only a small amount of maintenance. Regular cleaning and removal of solids from the screens is required to ensure consistent flow.

Adequate provision for downtime, such as scheduled maintenance, should be taken into consideration. Greywater plumbing should be connected to the mains sewer to allow immediate diversion for greywater disposal. Provision for potable mains water should also be included for temporary toilet flushing when needed.

Blackwater

All sewer mining systems require regular maintenance. The technology selected will determine the maintenance management schedule required. Membrane filtration processes, for example, require regular chemical or physical membrane cleaning, with eventual membrane replacement.

Operation can be affected by variable wastewater quality, potentially harming the system. A peak caustic load in the sewer from an industrial customer is an example of a potentially harmful variable in the system. Regulatory approaches have minimised these occurrences. Licence agreements stipulate pollutant loads, supported by advanced approaches to tracking rogue customers.

All

The Victorian Government has stated that recycled water services that use wastewater from public sewerage systems are the responsibility of publicly owned water authorities, and that legislation and guidelines will soon be introduced to better clarify the responsibilities for recycled water. In reality, there are some water recycling projects that the retailers are not involved in directly (such as the City of Melbourne's CH2 building). Currently there is no Victorian

Government position on the transfer of water recycled from one property to another (eg sharing amongst neighbours), and consultation is required with water authorities and regulatory bodies to clearly define rights and responsibilities.

A risk assessment should be undertaken for water recycling projects to ensure risk to human health is minimised. One recommended assessment is Hazard Analysis and Critical Control Point (HACCP). The risk assessment is recommended as there are currently no Victorian Government guidelines for water quality standards and risk analysis associated with water recycling projects.

Some water treatment systems will generate waste residues, and in some instances these residues will be heavily contaminated. Suitable consideration and management of all wastes must satisfy EPA requirements.

8.2 Evaluation

The City of Melbourne acknowledges that WSUD is new in its application and that there will be teething problems. Because of this, our commitment to evaluation is very high to ensure that WSUD is given every chance to succeed as a means of saving water and improving water quality.

Targets and Monitoring

Targets will be used in WSUD applications, providing measurable goals. The targets have been set out in these guidelines as well as in *Total Watermark*. All projects will be measured against these targets.

Monitoring will link to these targets to demonstrate the effectiveness of applied measures. This information will influence future decisions on land-use design for sustainable water management.

For projects undertaken by developers, the City of Melbourne is piloting the Clean Stormwater project with Melbourne Water. This assessment tool measures likely reductions in stormwater pollutants achieved by different designs. In piloting this tool we can also access this data for monitoring the effectiveness of WSUD.

Maintenance

As set out in Section 8.1 maintenance procedures will be very thorough in the initial stages of implementing WSUD. Street maintenance procedures will vary significantly due to WSUD, and the City of Melbourne will conduct pilot studies to assess changes required in design, practices and education.

9 Useful links and resources

More information on water sensitive urban design (WSUD) elements and case studies are available online.

9.1 Melbourne Water

The urban water cycle is accessible from Melbourne Water's main page. This section includes information of onsite recycling initiatives.
http://www.melbournewater.com.au/

Broader information on Melbourne's stormwater is available from Melbourne Water Stormwater site. http://stormwater.melbournewater.com.au/

Melbourne Water has a website devoted to WSUD with information including:
* Victoria's WSUD technical manual;
* fact sheets;
* treatment tools (swales, infiltration trenches, bioretention systems, wetlands, porous paving, rain gardens, rooftop greening);
* integrated water cycle tools (rainwater tanks, greywater reuse); and
* case studies, estates and conceptual layouts.

Water conservation initiatives, water wise gardening techniques and home water investigation are accessible from Melbourne Water's 'conserve water' website.
http://conservewater.melbournewater.com.au/

9.2 South East Water

South East water provides information for consumers (business and residential) to conserve water and alternate water sources such as rainwater tanks and greywater systems. www.southeastwater.com.au

9.3 City West Water

City West Water provides information for water conservation. Refer to the relevant section under the Environment section. www.citywestwater.com.au

9.4 EPA Victoria

The Environmental Protection Authority (EPA) Publication 812 (Nov. 2001) *Reuse Options for Household Wastewater*.

A list of EPA approved wastewater treatment systems and Onsite wastewater systems information can be viewed on the Vic EPA's website. http://www.epa.vic.gov.au/Localgov/

9.5 Victorian Government

Department of Sustainability and Environment. www.dse.vic.gov.au

The Victorian Government has a commitment to conserve water. The *Our Water Our Future* initiative encompasses the water rebate program, water education issues and current information on water restrictions. www.ourwater.vic.gov.au

Smart water fund established to promote water conservation and recycling initiatives. www.smartwater.com.au

9.6 Useful Links

Australian Water Association (AWA). www.awa.asn.au

Australia's leading source on water conservation issues, primarily sponsored by Yarra Valley Water and RMIT Centre for Design. www.savewater.com.au

Water Services Association of Australia provides information on the national water efficient rating and labelling scheme. Consumers can search for '5A' fittings and appliances. www.wsaa.asn.au

Green plumber association. www.greenplumbers.com.au

Sustainable Gardening Australia. www.sgaonline.org.au

Alternative Technology Association. www.ata.org.au

International Water Association (IWA). www.iwahq.org.uk

9.7 References

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Victoria EPA (1996) Code of Practice - Septic Tanks - publication 451

Victoria EPA (2003) Guidelines for Environmental Management: Use of Reclaimed Water - publication 464.2.

Victoria EPA (2001) Reuse options for household wastewater - publication 812.

Victorian Government White Paper (2004) Securing Our Water Future Together

Victorian Government (2002) Melbourne 2030, Planning for sustainable growth.

Victorian Urban Stormwater Best Practice Environmental Management Guidelines (R. Allison, T. Wong, P. Breen)

Water resources strategy committee (2003) 21st century Melbourne: a watersmart city - Planning for the future of our water resources

Wong, T (Ed) (2003) Australian Runoff Quality

Section Two: Table of Contents

Case Study overview

This section presents a series of case studies for the City of Melbourne. The case studies combine water sensitive urban design (WSUD) elements to illustrate typical applications. The case studies are based on realistic sites, with real constraints.

The case studies are intended as ideas only and are not agreed or approved site plans. Discussions must be held with relevant land managers to better understand site constraints beyond water, and to discuss the viability of potential application to sites.

Case Study	Development Type	Scale	Target audience	Key WSUB features
1. The Terraces	Infill development	Site	Residential and City of Melbourne	Rainwater harvesting Light greywater reuse
2. The Tivoli building	High rise commercial building	Site	Business and developers	Demand management Sewer mining
3. Docklands style development	Multi-storey residential/commercial	Regional and precinct	Developers	Stormwater treatment and reuse Stormwater management
4. Carlton Gardens	Par and public	Precinct	City of Melbourne	Rainwater harvesting Sewer mining
5. Queen Victoria Markets	Public building	Precinct	City of Melbourne Large land owners	Rainwater harvesting Stormwater management
6. Ryder	Sporting field	Precinct	City of	Rainwater

Oval Pavilion	amenities block		Melbourne	harvesting Light greywater reuse
7. Dynon Rd	Stormwater canal rehabilitation	Precinct	City of Melbourne	Stormwater management State agencies
8. Dodds St	Streetscape renewal	Precinct	City of Melbourne	Stormwater management

1 The Terraces

This WSUD case study is applied to an existing residential redevelopment site. The case study was undertaken after the commencement of works on-site, and as such the WSUD ideas expressed below were not able to be fully incorporated. Despite this, the developers were able to redesign the roof to enable greater rainwater harvesting and facilitate the use of rainwater for toilet flushing in T1 and T2. This is in addition to water efficient fittings and pressure limiting valves.

1.1 Nature of the development

The City of Melbourne, Archicentre and the Victorian Building Commission are redeveloping two single storey terraces in Carlton. The redevelopment aims to showcase innovative and practical renovations highlighting industry best standards and practices in a contemporary style.

The two terraces (T1 and T2) are mirror images of each other and are situated in Elgin St, Carlton. Carlton is an inner city site, recognised for its historic character. The terraces were originally built in 1886. As such the entire street is heritage listed with height restrictions and requirements to protect the facades.

Refer to Archicentre's website for the full brief and for up to date information and project tracking http://www.archicentre.com.au/theterraces/

1.2 Water Sensitive Urban Design (WSUD) objectives

* *Total Watermark 2004* targets an absolute 40 per cent potable mains water reduction for all residents (from 1999 level).

* Treat stormwater runoff to meet Victorian Government guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and 70 per cent reduction of litter entering stormwater from the site. This would reduce pollutant loads to stormwater systems and Port Philip Bay.

1.3 Site constraints

The terraces are recognised as historically significant. The buildings' facades cannot be altered due to historical requirements which limit the development height, as well as the potential for water harvesting from the front roof section.

The terraces are inner city allotments with small roof areas (approximately 45m2 available catchment), which limits the potential for rainwater harvesting.

Future immediate ownership of the terraces is unknown.

1.4 Opportunities of WSUD

The water cycle strategy is summarised in Table 1 and each element then discussed. To reduce potable mains water demand, the terraces should be fitted with water efficient devices and appliances. These include water efficient showerheads, tap aerators, mixing taps with a 'water brake', AAAA appliances (washing machines), 6/3L dual flush toilets and smart irrigation systems. Pressure reduction valves, typically installed at the property boundary, reduce delivery pressure and therefore minimise water loss.

The objective of water reuse is to replace potable water use with other water sources where the quality is fit-for purpose. Rainwater is a potential source for both terraces. Light greywater collection and reuse is more appropriate for T2, as the roof catchment is small and the bathrooms are situated on the first floor enabling easier wastewater collection from the showers.

The installation of a 1.5 kL rainwater tank is recommended for T1. The rainwater water can be used for toilet flushing. Combined with water efficient appliances and fittings, potable mains water demand is reduced by 40 per cent and limits stormwater runoff from the site.

It is noted that if the development was at an earlier stage the roof could be reconfigured to catch more water and the tank located in the roof space.

Table 1.

Suggested water cycle strategy for each terrace

Water cycle strategy	T1	T2
Demand management	Installation of water efficient appliances, pressure reduction valves, 3/6L dual flush toilets, etc.	
Rainwater harvesting	1.5 kL rainwater tank Use - toilet flushing	2 kL rainwater tank Use - hot water
Light greywater reuse	Not available	Use - toilet flushing
Potable main water conservation	40 %	80 %

A light greywater treatment system and a 2000 litre rainwater tank are recommended tor T2. With the availability of treated greywater for toilet flushing, the preferred use for rainwater is hot water.

1.4.1 Rainwater harvesting - T1 and T2

Rainwater can be harvested from the terraces and used on site. Sizing of a rainwater tank depends on rainfall quantity and frequency, the catchment surface area (~45m2) and the rainwater use. The rainwater use determines quantity and frequency. For example, using water for toilet flushing requires rainwater every day whilst using water for garden irrigation has peak demands during summer.

Rainwater tanks can be sized by using the specialised sizing curves (refer to fact sheet 2a). These curves relate Melbourne's rainfall pattern and expected uses to available catchment area. The curves were created by a software package called MUSIC was developed by the Cooperative Research Centre for Catchment Hydrology to account for these variables.

For this case study, the rainwater tanks were sized using MUSIC stormwater modelling software. The model assumed two people were living in the household with 90 L/day hot water demand and 50L/day for toilet flushing.

A first flush device is installed to divert the first 1-2 mm rainfall thereby preventing debris and pollutants from entering the rainwater tank. Screens and meshes are installed on the tank's inlets and outlets and on roof gutters to prevent debris collection and mosquitos.

1.4.2 T1 - rainwater harvesting

A schematic of the rainwater harvesting system for T1 is shown in Figure 1. Rainwater is collected from the roof and stored in a tank. A small trickle pump (that can be solar powered), pumps water from the storage tank to a header tank (50-100L capacity) to supply the toilets.

A potable mains water connection, with an air gap, is required to supplement rainwater with an appropriate connection to the header tank. Any rainwater tank must conform to Australia Standards (AS3500) with licensed plumbers required for correct installation.

A tank sizing curve is produced for the terraces with a 45m2 roof area in Figure 2. Rainwater supply reliability (i.e. the amount of water supplied by rainwater) (on the vertical axis) varies with tank size (shown on the horizontal axis) and water demand (the different curves). Reading from Figure 2, for a 50 L/day demand (toilet flushing - green curve) a 1.5 kL rainwater tank providing 87 per cent supply reliability. Note additional information for sizing rainwater a tank is supplied in fact sheet 2a.

1.4.3 T2 - rainwater harvesting

A schematic of the proposed rainwater harvesting section is shown in Figure 3. In this situation a consumption of 90 L/day is suggested for hot water usage. The rainwater tank sizing uses the same approach as outlined in example T1. Referring to Figure 2 and observing the orange line, a 2 kL tank provides a 65 per cent hot water supply reliability. For this application the system is limited by the small roof area with normal operating conditions requiring potable mains water top up. Thereby the potential rainwater use is maximised and potable mains water conservation is optimised.

For T2 the rainwater is treated by the hot water system, with heating to 60 degrees C providing adequate microbial treatment. At this temperature, any pathogens are destroyed minimising risk to public health.

1.4.4 T2 - light greywater reuse

Potable mains water demand can be further reduced through the use of light greywater for toilet flushing with any surplus used for garden irrigation. Light greywater is the cleanest wastewater stream from the household, collected from the shower, bath and hand basin in bathrooms. An overview of a greywater system is shown in Figure 4.

Light greywater contains contaminants and is unfit for human consumption. Typically these contaminants are low levels of bacteria, faecal matter, organic matter, micro-organisms and detergents. Organic material, if not removed, can cause the greywater to discolour, become anaerobic and give off odours. Care must be taken to limit human exposure to greywater, which is achieved by a closed system with treatment.

For systems treating less than 5000L/day, EPA Victoria has provided a list of approved greywater treatment systems. The City of Melbourne can issue permits for EPA approved systems. The approved greywater devices are listed on the EPA Victoria's website (www.epa.vic.gov.au) and EPA publication 812 provides further advice for greywater reuse. Note EPA approval is not required for a closed system, that is, when no water is released to the environment.

The Department of Human Services has also prepared guidelines for the greywater reuse, available from their website (www.health.vic.gov.au/environment/).

Technology selection is dependent on desired water quality, footprint available and the overall treatment train. A schematic illustration is shown in Figure 5. The mesh screen physically removes larger objects from the process. The separator removes fats, oils and grease. The subsurface flow wetland has the dual purpose of regulating 'in' flow and water treatment. Sedimentation removes larger sized pollutant and pathogens and dissolved organic matter are reduced by the biological treatment. Refer to fact sheet 4a for additional information.

Depending on the specific reuse, greywater may required further disinfection, such as chlorine disinfection (refer to fact sheet 5f). Finally the storage tank provides a reservoir to meet residential demand that varies over a typical day to supply. A header tank is required approximately 60-100L - i.e. approximately 24 hour demand to provide sufficient pressure and storage for demand.

Adequate provision for non-operating time, such as scheduled maintenance, is required. The treatment system should incorporate a bypass to sewer as shown in Figure 4.

1.4.5 Light greywater treatment - indicative sizing

Based on a two bedroom terrace (approximately two people per household) employing efficient household devices that includes the installation of AAA fittings (showerhead, flow regulators), 100L/day of light greywater is expected.

After collection, the greywater is treated in a constructed wetland (surface area of 1 m2) then reused for toilet flushing. There is a greater greywater flow rate (100 L/day) collected than required for toilet flushing (50 L/day). The excess may be used for irrigation, though the small garden area (18m2) limits demand.

Untreated light grey water could be stored for up to 24 hours. After this period the surplus water should be discharged to sewer which is set up to occur automatically.

The 'cascading' rainwater tanks provide an ideal opportunity for a contemporary urban wetland in a small confined backyard. The wetland can be constructed on top of the tanks as shown in Figure 6.

The required wetland surface area (1.0 m2), based on an average flow of 100L/day can be accommodated on top of the first cascading tank (area 1.3m2). The inlet water is fed to the wetland through subsurface pipes (refer to Figure 7). The water percolates through the gravel media. Here the wetland vegetation decomposes the organic content, reduces nutrient loadings and removes particles and pathogens. The water flows to the outlet collection pipe, which is situated just below the surface, and then to the storage tank. An overflow pipe is required for maintenance and flood prevention as indicated in Figure 7.

The wetland is 0.5 m deep to support gravel drainage, root zone and adequate vegetation. The bottom 100mm contains coarse gravel (10-20mm) and the top 400mm is gravel (3-5mm). The model media for subsurface flow wetlands is a washed river gravel (3-5mm) which will have an initial hydraulic conductivity in excess of 4m/hour. Other stable media can be used as long as they fit the general requirements to allow good plant growth. A range of plants can be grown in subsurface wetland system to suit most landscape requirements. Typical species could include: Baumea articulate, cyperus lucidus, carex fascicularis (natives) or cyperus involucratus, Iris pseudoacorus, canna species (exotics). Refer to fact sheet 4a for additional information on subsurface wetlands.

All installations must conform to Australian Standards, with reference to AS3500.1.2 Water Supply: Acceptable Solutions, wastewater treatment (AS1546) and wastewater effluent management (AS1547), and plumbing requirements. A licensed plumber is required to install the system. Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for additional information.

1.5 WSUD Performance

Installation of water efficient appliances and demand reduction typically reduces water consumption by 15 per cent. The combination of demand management and rainwater as hot water, as recommended for T1, has potential water saving of 40 per cent.

The combined options of demand management, rainwater for hot water and greywater for toilet flushing and garden irrigation (as recommended for T2) has a potable mains water saving of 80 per cent.

Site stormwater runoff will be minimised by rainwater harvesting, thereby minimising this site, albeit a small portion of the total catchment, nutrient loading to Port Phillip Bay.

2 The Tivoli building

This case study is applied to an existing high-rise building used for retail and educational purposes. The building has successfully implemented a rooftop garden and rainwater scheme. The additional WSUD ideas set out in this case study have been proposed independently of the work plan for Tivoli, and as such are not considered for implementation.

The case study is presenting WSUD options for a high-rise commercial building.

2.1 Nature of the development

The Tivoli building is a large commercial building owned by RMIT at 235-251 Bourke St, Melbourne. The building is a combination of office space, lecture halls, tutorial rooms, student amenities and shops. As such, there is a combination of regular building users including university staff and shopkeepers with a transient population consisting of students and shoppers.

The Tivoli building demonstrates WSUD with the incorporation of a Plaza garden and a rainwater supply. The Plaza garden has the dual purpose of increasing the impervious area and providing an aesthetically pleasing environment for occupants. The advantage of the increased impervious area is the capture and in situ stormwater treatment minimising pollutant loading to receiving water bodies.

The harvested rainwater is collected from the rooftop and stored. A dedicated and separate non-potable water plumbing system is connected to the toilets and irrigation system. The harvested rainwater is then used for toilets and for Plaza garden irrigation.

Currently there is insufficient rainwater available, due to limited available catchment (roof area) to meet demand. Potable mains water is used to supplement this supply. This project examines options to expand the existing WSUD application.

2.2 WSUD objectives

WSUD objectives for the Tivoli Building are to be consistent with *Total Watermark 2004* and best practice to include:
* *Total Watermark 2004* targets an absolute 40 per cent potable mains water reduction for employees and residents
* treat stormwater runoff to meet state guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and 70 per cent reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

2.3 Site constraints

The Tivoli building is an existing structure with WSUD features incorporated into the building. The building's WSUD features include a roof garden and a separate 'non-potable' water supply. Rainwater is harvested from the roof top and used for toilet flushing and irrigating the Level 4 roof top garden.

Melbourne's CBD has limited alternative water supplies and potential water uses. Retrofitting projects must be able to complement the building's existing setup and infrastructure.

2.4 Opportunities of WSUD

Demand management strategies, including water efficient appliances have reduced water demand throughout the building. The main 'non-potable' water requirements are toilet flushing (there are 288 toilets and 15 urinals throughout the building) and for irrigation of the rooftop garden, situated on the plaza level (Level 4) of the building. An estimated 6.2ML/yr of non-potable water is consumed *1.

The available roof area (approximately 1046 m2) harvests 1.8ML/yr of rainwater *2. There is potential to further reduce potable mains consumption by supplementing the rainwater with an appropriate water source.

2.4.1 Blackwater reuse

Alternative water can be provided from blackwater. Extracting water from the sewer for reuse is known as sewer mining. Treatment systems typically consist of sewer extraction, screening and treatment before reuse. The pumping systems are designed to minimise solids extraction, thereby minimising treatment costs. The solids are separated and immediately returned to the sewer for centralised treatment (i.e. at a sewerage treatment plant). The water is then further treated and disinfected to an appropriate quality, typically to class A standard. The disinfected reclaimed water is then ready for reuse. Sewer mining systems are typically a combination of technologies to extract and treat sewerage. They can be purchased as 'package treatment plants' and can be suited in the building's basements. Refer to fact sheets 5a, 5d and 5e for typical treatments.

The Tivoli building is adjacent to City of Melbourne's CH2 building, where a sewer mining system is already planned for this building. Potential exists to increase CH2's wastewater treatment plant capacity and supply the Tivoli's building with additional water. The existing 76kL storage tank located in Tivoli's building basement can be utilised to provide buffering capacity for the sewer mining system. The water is then pumped to existing large header tanks on the roof and is available for toilet flushing and garden irrigation.

The increased sewer mining plant capacity will reduce overall operating costs. Operating agreements and communication between CH2 and the Tivoli building will be required.

2.4.2 Stormwater treatment

Minimal stormwater runoff is generated by the site currently. Harvesting rainwater limits the pollutant loading to receiving water bodies by stormwater reuse and capture. Additionally the roof top garden treats stormwater as it infiltrates through the soil via a combination of physical and biological processes.

2.5 WSUD Performance

Additional water supply from sewer mining will provide sufficient water to meet 'non-potable' water requirements reducing potable mains water consumption by 4.6 ML/year. Including rainwater harvesting, a total of 6.2 ML/yr of potable mains water will be conserved. This equates to approximately 40 per cent of total water usage in the building. Stormwater runoff will be minimised by the harvesting roof runoff to 'top-up' water supplies.

Tivoli building - sewer mining

Sewer mining systems - extract water from the sewer, removing solids and treating water for reuse. Technologies are available in package treatment plants with a small footprint, approximately 60m2. The systems can operate according to demand with little space required for storage. Water is treated, reducing organic concentration and pathogen levels. Typically disinfection is required before water reuse

Typical plumbing arrangement

Wastewater treatment plants can be designed to fit in building's basements. A separate delivery system for the treated water is required. Adequate bypasses are provided for scheduled maintenance.

Sewing mining

A primary separation process usually follows extraction to remove remaining solids. Screening is the most common physical separation process employed, with the screened solids returned immediately to the sewer. Wastewater can be used to continually clean the screen, thereby preventing clogging. Variations on pre-treatment include hydro-cyclone separators, sedimentation, enhanced sedimentation and dissolved air flotation (DAF) devices.

Sewer mining technologies

Sewer mining treatment must reduce the high organic and micro-organism concentrations and control pathogen levels. Technology design parameters will accommodate the changes in water characteristics and pollutant loading. A range of treatment technologies can be employed for sewer mining with appropriate technologies including:
* Subsurface flow wetlands (refer to fact sheet 4a);
* Suspended growth systems e.g. activated sludge systems and sequencing batch reactors (SBR), (fact sheet 5a);
* Fixed growth systems e.g. trickle filters, rotating biological contactors (RBC) (fact sheet 5b);
* Recirculating media filters (fact sheet 5c);

* Membrane bioreactors (fact sheet 5a);
* Filtration e.g. sand filtration and membrane filtration (including reverse osmosis) (fact sheet 5d and 5e);

These technologies are described more detail in the appropriate fact sheet. This list is indicative; with more technologies emerging with increased competitiveness and innovation.

Disinfection

Disinfection minimises pathogenic microorganisms and thereby ensures public health. Disinfection destroys pathogenic microorganisms in water. Eradication of waterborne pathogens is the most important public health concern for water treatment. Chlorination and UV disinfection (shown right) are the most common methods. Refer to fact sheet 5f for more details.

3 Docklands development

The Docklands case study considers WSUD implementation at the larger precinct scale and outlines WSUD initiatives that have been implemented on the ground. This case study outlines existing initiatives and goes further to suggest possible greywater reuse/sewer mining that could also be applied to a site of this scale.

3.1 Nature of the development

Docklands is a major redevelopment of the Victoria Harbour precinct, east of Melbourne's CBD. It covers 200 hectares of land and 7 kilometres of water front. Docklands is a large scale contemporary urban development. By 2015, Docklands is expected to be home to 20,000 people, a place of work for 25,000 and a visitor destination for 55,000 people per day *3.

Docklands consists of a mix of residential and commercial medium density and high rise developments. The Docklands rejuvenation project provides an unique opportunity to combine water sensitive urban design (WSUD) into modern urban design. Opportunities exist to incorporate WSUD at a regional, precinct and individual site scale. Streetscapes, surrounding urban infrastructure and public open spaces can accommodate WSUD elements.

3.2 WSUD objectives

The Docklands Authority (now VicUrban) has a strong commitment to implementing sustainable design principles throughout the Docklands precinct. For stormwater management this encompasses stormwater runoff treatment for receiving waterways protection, stormwater runoff recycling (e.g. for open space irrigation) and flood management.
The objectives are:
* demand management (minimise water consumption)
* maximise stormwater reuse for open space irrigation
* treat stormwater runoff to meet state guidelines, specifically 80% reduction of total suspended solids (TSS), 45% reduction of total phosphorous (TP) and total nitrogen (TN) and 70% reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

3.3 Site constraints

Victoria Harbour's hydrodynamics are complex and are influenced by tides, Yarra River inflows and the prevailing winds. Modelling studies show that the harbour is permanently stratified. There is a lower salt water level, a fresh water level and mixed layer in between. Fresh surface water from the Yarra River flows into the harbour under both wet and dry flow conditions. The fresh water inflows entrain seawater to form a mixed layer, which constantly flows out of the harbour. Stormwater flowing to the surface has a long residence time in Victoria Harbour. Untreated stormwater (with high nutrient loadings) lead to environmental problems such as red algal growth. Therefore stormwater discharged directly to Victorian Harbour must flow into the mixed layer (as mandated by Docklands Authority). This maximises dispersion and minimises adverse ecological impacts.

Precinct scale public open space areas provide an opportunity to integrate stormwater collection, treatment and storage/reuse facilities within the overall landscape design. With competing uses for these spaces the scale and landscape form of the stormwater management systems needs to carefully consider the other park uses and their potential interaction with the stormwater management systems. Public safety and aesthetic amenity issues are important design considerations requiring site analysis to determine site usage patterns, journeys, site lines, and existing landscape character in order to ensure an appropriate landscape form.

3.4 Opportunities of WSUD

The Docklands development provides opportunities to integrate WSUD elements throughout the precinct.

The key areas considered in more detail for WSUD are:
* a stormwater collection, treatment and reuse scheme for Docklands Park;
* stormwater collection and treatment in a contemporary wetland from the NAB building and forecourt;
* stormwater collection and treatment from the Grand Plaza and Harbour Esplanade;
* stormwater treatment along the Bourke and Collins Streets extensions;
* stormwater treatment for Victoria Harbour wharf;
* stormwater treatment for Batman's Hill precinct; and
* discharge stormwater to Victoria Harbour at appropriate depth to maximise dispersion.

3.4.1 Dockland Park, the wetlands and stormwater reuse

Docklands Park is a significant green public open space covering 2.7 ha including three wetlands. Docklands Park provides insufficient catchment for stormwater harvesting to meet irrigation demand. However, the adjacent urban catchment provides opportunities for stormwater harvesting, treatment and reuse. Stormwater runoff from the National Australia Bank's (NAB) building roof and forecourt, Harbour Esplanade, Grand Plaza, and a portion of the Bourke St extension are collected for reuse. The water is directed (either by gravity or pumped) to Docklands Park. Docklands Park incorporates three wetlands, which function as a stormwater treatment system as well as a modern urban landscape feature.

Landscape designers for Docklands Park indicated that the maximum size of wetlands that could be incorporated into the overall landscape design of the park would be notionally 1475m2. Three wetlands with this overall dimension could treat approximately 80 per cent of the annual stormwater runoff generated from the overall catchment area of 4.8Ha (this assumed the catchment area is 80 per cent impervious). The wetlands treat collected stormwater by physical and biological processes reducing total suspended solids (TSS), nutrients (nitrogen and phosphorous) and pathogens. Wetlands are further discussed in fact sheet 4b.

The treated stormwater is stored underground. Three underground storages totalling 500m3 are situated adjacent to the wetlands. Treated stormwater reused for park irrigation substantially reduces the annual potable mains water consumption.

3.4.2 Commercial building (NAB building) and forecourt

Stormwater from the NAB roof and surrounding courtyard is collected and directed to a constructed wetland situated in the forecourt. The wetland is designed in the shape of an 'exclamation mark', providing a landscape feature and functioning water treatment system. The water enters the 'full stop', a sediment basin, removing coarse sediment (refer to Fact sheet 3c). Water then flows to the wetland (refer to fact sheet 4b) for treatment before underground storage, and reused for irrigation of Docklands Park.

An open north-south corridor exists within the NAB campus style buildings. Stormwater collected in this area is treated through a sand filter (refer to Fact sheet 5d) before discharge to the Yarra River.

Presently, the NAB building is supplied for potable mains water for all purposes. An opportunity exists to reduce potable mains water consumption by supplementing with an appropriate source. The NAB building's highest potable mains water demand is for toilet flushing. Insufficient roof runoff is generated to meet this demand and the stormwater is collected and used in Docklands Park. An alternate water source, such as greywater from an adjacent high rise residential building, is appropriate for toilet flushing. Supply to toilets should be plumbed with a separate pipeline and header tank throughout the building. This suggested strategy is reliant on the completion of both the commercial and residential development. Initially, insufficient treated greywater is available and potable mains water is supplied for toilet flushing in the NAB building. As development increases, residential greywater generation increases providing a water source for toilet flushing.

3.4.3 Grand Plaza and Harbour Esplanade

The Harbour Esplanade runs along the water front, south of Telstra Dome, while the Grand Plaza connects the wharf to Harbour Esplanade. Both regions have high impervious areas from the plaza, footpaths and streets. Stormwater flowing from these areas require treatment prior to discharge. The existing infrastructure includes a culvert between the tram line and the planned Grand Plaza deck. The culvert provides an opportunity for temporary storage for stormwater runoff from Harbour Esplanade and Grand Plaza. This runoff stormwater is then pumped to the Docklands wetland for treatment.

Runoff from Harbour Esplanade flows directly to the storage culvert. Grand Plaza runoff will initially run through gross pollutant traps to remove litter, coarse sediments and other debris (refer to fact sheet 3d for additional information). The water is then temporarily stored in an adjacent underground culvert.

Overflows will be permitted for flows in excess of the three month ARI (average recurrence interval). These overflows will discharge directly into Victoria Harbour. Discharge level is determined by Victoria Harbour's hydrodynamic behaviour, with water discharged to the 'mixed' layer maximising dispersion.

There is potential to fit stormwater treatment measures such as bioretention systems (e.g. swales, basins, trees), buffer strips and vegetated swales along the Esplanade to provide stormwater treatment at source.

3.4.4 Bourke and Collins St extensions

The extension of Bourke and Collins Streets provides opportunities to incorporate stormwater treatment measures into the streetscaping. Street tree lined landscaping provides opportunities for tree planter bioretention systems. Each bioretention system is installed at the tree's base. Stormwater runoff flows from the street catchment flows into the bioretention tree. Stormwater will infiltrate through the selected media for treatment. The combined media and tree's root zone treat the stormwater reducing suspended solids, nitrogen and phosphorous levels (refer to fact sheet 3b).

Treated water then either drains to the Harbour Esplanade or the Yarra River. The Bourke St extension along the NAB building will be graded to drain to east towards Harbour Esplanade and hence be collected for reuse. West of the NAB building will drain to the Yarra River. Flows greater than the three month ARI will discharge to the Yarra River via a conventional pipe system. Major event flows will be directed to Victoria Harbour, the natural low point.

3.4.5 Victorian Harbour Wharf (Promenade)

The Victorian Harbour wharf is along the southern side of Victoria Harbour. A series of bioretention cells will treat stormwater before discharge into Victoria Harbour (refer to fact sheet 3b). Bioretention effectively reduces suspended solids and nutrients. Vegetation in the bioretention cell can be selected to suit the landscape design. Limited opportunity exists to reuse this relatively small water amount. The discharge pipe must be located at a suitable depth that is in the 'mixed' layer below mean sea water level.

3.4.6 Discharges directly to Victoria harbour

Treated stormwater runoff and untreated discharges resulting from events larger than the three-month ARI peak discharge from the wharf areas surrounding Victoria Harbour can be discharged directly to the harbour in accordance with the following requirements:
* the discharge point should be located as far as possible toward the mouth of the harbour; and
* the outfall pipe level should be minimised to direct discharge to the 'mixed' layer.

This will ensure stormwater discharges into Victoria Harbour will undergo maximum mixing with the sea water avoiding the creation of a stormwater 'slick' on the harbour surface.

3.4.7 Batman's Hill precinct

A combination of WSUD elements systems are situated strategically throughout site. Bioretention systems are configured to complement streetscape and landscape feature including; roadside linear bioretention systems adjacent Waterview Walk, and Stadium Drive, planter boxes along Wurundjeri Way and 'rain gardens' incorporated to East Rd's car park. A detention basin is combined with stormwater quality treatment, a bioretention basin, situated in the south east corner. Linear hard edged wetlands adjacent to west road enhance aesthetics and provide effective stormwater treatment.

3.5 WSUD Performance

Stormwater treatment will meet the objectives established for the project. Potable mains water will be conserved by stormwater harvesting and reuse scheme for Docklands Park. This reuse treatment scheme minimises site stormwater discharge, thereby protecting the aquatic ecology of Victoria Harbour.

Water sensitive urban design options for Docklands precinct

Water Quality

Victoria Harbour

Victoria Harbour is stratified with fresh, mixed and salt layers. Peak flow stormwater is discharged into the 'mixed' layer to maximise dispersion. Discharge pipe should be situated at appropriate height and positioned towards the mouth to maximise mixing.

NAB building and forecourt

Stormwater runoff from the building and forecourt are directed to the exclamation mark wetland in the forecourt. The water is then directed to Docklands Park for storage.

Victoria Harbour wharf promenade

Stormwater runoff from the building and forecourt are directed to the exclamation mark wetland in the forecourt. The water is then directed to Docklands Park for storage.

Bourke St and Collins St extension

Bioretention tree planters are installed in the street extension to treat stormwater at source. Treated water is discharged to the Yarra River through a conventional drainage system.

Grand plaza

Stormwater runoff will run through gross pollutant traps to remove litter and then into an adjacent storage culvert. Water is then pumped to Docklands Park wetlands for treatment.

Harbour Esplanade

Stormwater runoff is collected in an adjacent culvert. Water is then pumped to the wetlands in Dockland Park for treatment. Opportunities exist for bioretention system along the Esplanade.

Docklands Park

Three free surface wetlands are situated in Docklands Park to treat stormwater runoff from the Grand Plaza, Harbour Esplanade, NAB building and forecourt. Treated water is stored in adjacent underground storages. This water is used for Docklands Park irrigation.

Constructed wetlands

Stormwater runoff from NAB building, forecourt plaza, Harbour Esplanade and Grand Plaza is treated as it flows through the three constructed wetlands. The wetland reduced total suspended solids (TSS), nutrients (TP and TN) by physical and biological processes.

Batman's Hill Precinct

A combination of WSUD elements systems are situated strategically throughout site. Bioretention systems are configured to complement streetscape and landscape feature including; roadside linear bioretention systems adjacent Waterview Walk, and Stadium Drive, planter boxes along Wurundjeri Way and 'rain gardens' incorporated to East Rd's car park. A detention basin is combined with stormwater quality treatment, a bioretention basin, situated in the south east corner. Linear hard edged wetlands adjacent to west road enhance aesthetics and provide effective stormwater treatment.

NAB building and forecourt

Commercial building

Water efficient fittings and appliances should be installed. Potential exists for toilet flushing water to be supplied from a greywater reuse scheme from an adjacent residential building (where greywater production surpasses demand).

Bourke St extension

Bioretention systems as tree planters treat stormwater before discharge to the Yarra River. A small number are directed towards the Docklands Park reuse scheme.

Exclamation mark wetland

Stormwater runoff from NAB building and plaza treated in contemporary styled wetland. The 'dot' acts as a retarding basin withwater following through the wetland for treatment and aesthetic value. Water flows to Docklands Park for further treatment and storage.

Harbour Esplanade

Stormwater runoff is stored in an adjacent culvert before pumping to Docklands Park for treatment.

Stormwater runoff

Stormwater runoff from Victoria Harbour precinct is directed to Docklands Park by conventional drainage systems.

Grand plaza and Docklands Park, Melbourne Docklands development team - Ashton Raggatt McDougall, Rush Wright Associates, Ecological Engineering, Connell Wagner.

Stormwater treatment and reuse in Docklands Park

Constructed wetlands

Stormwater runoff from NAB building, forecourt plaza, Harbour Esplanade and Grand Plaza is treated as it flows through the constructed wetland. The wetland reduced total suspended solids (TSS), nutrients (TP and TN) by physical and biological processes.

The contemporary design of wetlands can incorporate hard edges to suit landscape designs. Refer to fact sheet 4b for additional information

Underground storage

Treated stormwater is stored in underground storage tanks. This water is used for garden irrigation with peak demands in summer.

'Exclamation mark' shaped stormwater treatment wetland signifying main pedestrian entrance to waterfront promenade, Grand Plaza

Victoria Harbour Wharf - Bioretention system for stormwater runoff

Victoria Harbour

Victoria Harbour is stratified - a top fresh water layer, bottom salt water layer and a middle 'mixed' layer.

Water must be discharged in the 'mixed' layer to maximise dispersion. This reduces potential environmental impacts.

Bioretention systems

Bioretention systems treat stormwater before discharge directly to Victoria Harbour. Little opportunity exists to reuse this relatively small amount of water. High flow water will discharge directly to Victoria Harbour at a prescribed depth. Bioretention systems are described in more detail in fact sheet 3b.

Bourke and Collins Street extension

Bioretention trees

Stormwater is filtered through a prescribed media (eg. sand) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system.

Refer to fact sheet 3b for more information.

4 Carlton Gardens

This case study outlines a possible scenario for an open space area in the City of Melbourne. The WSUD ideas expressed below are not scheduled to be implemented in Carlton Gardens, however consideration of the ideas will take place in the near future. City of Melbourne is currently considering the ideas below in other parks that have less heritage restrictions than Carlton Gardens.

4.1 Nature of the development

The historic Carlton Gardens are a Melbourne icon and the setting for the Royal Exhibition Building and the Melbourne Museum. The site has significant heritage value as it hosted the Melbourne International Exhibition in 1880, was the site of the first Australian Parliament in 1901 and was the first Australian building listed by the UNESCO World Heritage Council.

A masterplan has been drafted to restore Carlton Gardens, which aims to restore the historic features of the site including ornamental lakes, tree lined walkways, curved pathways and vegetation to reflect the original landscape design. The master planning process provides an opportunity to incorporate WSUD elements into the new design.

4.2 WSUD objectives

Parks and gardens are a high water consumer for the City of Melbourne, constituting 82 per cent of the City's total water consumption *4. WSUD objectives for the Carlton Gardens, the Royal Exhibition Building and the Melbourne Museum include:
* *Total Watermark 2004* targets an absolute 40 per cent potable mains water reduction for all employees and 40 per cent reduction for all council parks and gardens *5.
* treat stormwater runoff to meet state guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and a 70 per cent reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

4.3 Site constraints

The site's significant heritage value creates a unique opportunity to blend water sensitive urban design elements within a heritage garden context. The material selection and design, species selection and landscaping design can conform to the heritage requirements.

4.4 Opportunities of WSUD

Melbourne Museum and the Exhibition Building

In the Museum and Exhibition buildings, water demand can be reduced by the installation of water efficient fittings and appliances. Water efficient taps, toilets (6/3L dual flush), sensor activated urinals and pressure reduction valves will reduce water demand. In both buildings the highest potable (drinking) water demand is currently for toilet flushing. To conserve potable mains water, alternative water sources should be used for toilet flushing.

The Exhibition Building periodically hosts exhibitions, large functions and promotions. The building's transient use creates a highly variable water demand. Consequently retrofitting an alternative water source to the Exhibition Building will have limited value.

In contrast, Melbourne Museum has a regular water demand of approximately 3.3 ML/year *6 used for toilet flushing. The 2 ha roof provides a large potential rainwater catchment area. Rainwater harvesting will require a 200 kL tank to provide a 90 per cent supply reliability, with potable (drinking) water supplementing this supply (refer to fact sheet 2a for tank sizing).

Carlton Gardens

The gardens cover approximately 15.9 ha and the irrigation requirement for the gardens is high, especially through peak summer periods. To attain the City of Melbourne's 40 per cent potable mains water reduction goal, smart gardening techniques and alternative water sources are required. Smart gardening can reduce water demand by appropriate plant selection (xeriscape), moisture controlled irrigation systems, efficient water delivery (sub-surface irrigation) and mulching.

The irrigation water demand for 2002/03 was 62.6 ML. The installation of the modern automatic irrigation system to the Garden's northern section in 2004 will decrease demand. The total stormwater runoff has been determined at approximately 25ML/year, which represented less that half of the irrigation demand. Stormwater harvesting and reuse is further complicated by the seasonality of the irrigation demand. Additionally stormwater would be harvested in winter months (where demand is low) and required in summer months (where demand is high), thereby requiring large storages. The existing ornamental ponds have limited storage. Drawing down the water level in these ponds will create unsightly muddy edges unsuited for the site's heritage nature. Possibilities of stormwater storage tanks installed within the underground car parks, within future developments and beneath the ponds warrants further investigation. However, considering the large storage volumes required, rainwater harvesting appears unfeasible for garden irrigation.

Reclaimed water, such as sewer mining, could provide an alternative water source. The advantage being a small footprint with no onsite storage required. As demand increases through peak summer irrigation months, the extraction rate from the sewer can be increased. A typical package treatment plant to treat 100kL/day will cost approximately $400,000.

Stormwater treatment measures can be constructed throughout the gardens. Bioretention systems provide industry best practice for stormwater treatment. A series of bioretention systems (swales, basins and planter boxes) strategically situated along landscaped paths, garden beds and footpaths will treat stormwater before it is conveyed to Port Phillip Bay by existing drainage infrastructure. The bioretention systems can be designed in a heritage context with appropriate vegetation and materials selection.

4.5 WSUD Performance

The expected performance of this water sensitive urban design strategy is to reduce potable mains water consumption by 63 ML/year from garden irrigation and 3.3 ML/year by utilising rainwater for toilet flushing in the Museum. Stormwater discharge from the site will be treated to meet best practice stormwater quality objectives (80 per cent reduction of TSS, 45 per cent reduction of TN and TP).

Water sensitive urban design options for Carlton Gardens

Bioretention systems

Bioretention systems strategically positioned capture and treat rainfall from pavement and turf runoff. Their design can be suited to the park's landscape design. Bioretention systems can be configured as linear swales along paths and roadways, discrete cells or planter boxes to suit garden design. Typically bioretention systems are situated at low points in the land form.

Selected vegetation will be in keep with the heritage garden design.

Each bioretention system can capture and treat a defined catchment area. High flows bypass the treatment systems and are discharged via the conventional pit drainage.

Vegetated bioretention systems treat stormwater as it infiltrates through the filter media. Total suspended solids (TSS) are removed by filtration and nutrient levels (TP and TN) are reduced by physical and biological processes.

Water efficient gardens - exotic species can be selected to be in keeping with the heritage landscape design and water conservation aims. Vegetation selection and grouping will minimise water consumption.

Smart watering techniques and advanced irrigation systems (e.g. moisture controlled) will reduce water demand

Water efficient appliances - including toilets, tap fittings and pressure reduction valves can be installed in the Museum and Exhibition Building.

Sewer mining systems -

Sewer mining systems can be used to provide reclaimed water for garden irrigation.

Sewer mining systems extract water from the sewer, removing solids and treating water for reuse. Technologies are available in package treatment plants with a small footprint, approximately 60m2. Various technologies are explored in fact sheets 5a to 5e. The systems can operate according to demand with little space required for storage. Water is treated, reducing organic concentration and pathogen levels. Typically UV disinfection (refer to fact sheet 5f) is required before water reuse

Rainwater harvesting from the Museum's roof for toilet flushing

Rainwater collected from Museum roof, stored and then reused throughout the building for toilet flushing

Water storage

Possible storage underneath ornamental ponds and water features or underground. Possibility of incorporating water storage with streetscape art, such as an ornamental water features. Refer to fact sheet 2 for tank sizing, noting what large scale systems may require

Atlantis type underground tank cell - recycled plastic structure with high void space. This storage type can support high loads (up to 28 tonnes per m2) and can be used underneath lawns, pavements or footpath areas.

5 Queen Victoria Markets

This case study outlines a range of WSUD ideas for the QVM site including rainwater harvesting, stormwater treatment and water recycling. Whilst the ideas are currently not being implemented, QVM is pursuing funding for stormwater treatment in the carpark, and hopes to implement the remainder of the WSUD ideas in the coming years.

5.1 Nature of the development

The Queen Victoria Markets (QVM) covers 7 ha in the north of the City's CBD. The QVM is owned by the City of Melbourne and is operated by the Queen Victoria Market Pty Ltd. Queen Victoria Markets have been operated by the City of Melbourne for 126 years. The QVM is one of Melbourne's greatest 19th century architectural and functional examples, and is also the largest undercover market in Australia.

QVM is recognised as a tourist attraction and institution for Melbournians. The fresh food range includes fruit, vegetables, meat, fish, poultry and delicatessen lines. General markets include clothing, footwear, accessories and gifts. Currently the market operates five days a week, including weekends, with various operating hours.

Recent initiatives by the City of Melbourne and City West Water have reduced water consumption from 63.9 ML in 2002/03 to 59.8 ML in 2003/04 *7. Installation of water meters, stricter access to water, water efficient fittings, high pressure hoses for wash down, dual flush toilets, sensor controlled urinals and a greater water efficiency awareness have contributed and will continue to contribute to reduced water demand.

Currently Sheds H and I (selling organic fruit and vegetables and speciality foods) have no stormwater connection. The stormwater infiltrates through the soil for collection by the street drainage system. Council is presently planning to upgrade the stormwater system within this lower market section (bounded by Victoria, Elizabeth, Therry and Queen St), providing opportunities to incorporate WSUD elements throughout the site.

5.2 WSUD objectives

The objectives are to conserve potable mains water and treat stormwater to Victorian best practice.
* *Total Watermark 2004* targets an absolute 50 per cent potable mains water reduction for Council market sites *8.
* treat stormwater runoff to meet state guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and 70 per cent reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

5.3 Site constraints

Queen Victoria Market's historical significance has architecture dating to the 19th century, and as such all redevelopment must be in keeping with site's heritage character.

Melbourne's first cemetery is situated underneath the market and adjacent car park. Some bodies were exhumed and removed to Melbourne's General Cemetery but an estimated 8,000 to 10,000 bodies remain *9. Clearly this is a site that must be respected and recognised appropriately in any development. This limits excavation depth in the car park and potential underground water storages.

5.4 Opportunities of WSUD

Water usage throughout the site is highly variable ranging from washing food to washing down shed areas. The markets process and sell large quantities of consumable foods including meat, fish, fruits, vegetables and specialised food. Potable mains water should always be used for food preparation.

Currently potable mains water is used for toilet flushing and washing down market areas. Opportunities exist to use rainwater for these purposes. The Queen St toilet block consumed 6.7ML/year *10 in 2002/03. Cleaning practices include the wash down of sheds A & B, H & I with potable mains water. Rainwater should be used to wash down these surfaces. Roof runoff requires minimal treatment before reuse, provided a first flush system is installed. An estimated 10ML/year rainwater demand for toilet flushing and wash down purposes is realistic for the Queen Victoria market.

Queen Victoria Market's roof area is approx. 2 ha, providing a significant catchment area. With reference to fact sheet 2a, a 600m3 storage volume will provide 75 per cent supply reliability for the demands of the site, with additional water required to supplement supply. For example, the storage volume could be organised in a tank series throughout the market, for example a series of 20 tanks, 4.2m high and 3m diameter (total capacity 600 m3) designed and built with heritage considerations. Alternatives include fewer larger tanks or underground storage. Localised header tanks are also required for toilet block supply.

The lower market stormwater roof runoff from Sheds H & I, the food court, meat and diary hall are presently unconnected. Main stormwater infrastructure works requires drainage installation. This upgrade presents an opportunity for underground stormwater storage installation such as the Rocla 'ecoRain' tanks

*11 or equivalent. These are basically large diameter concrete pipes with high level weirs to store water. Overflows spill directly into the drainage system. The additional storage will supplement toilet flushing and wash down water, thereby increasing the overall rainwater supply reliability.

Stormwater upgrade and car park redevelopment provides opportunities to treat stormwater at source. Car park redesign can treat stormwater at source by incorporating integrated bioretention systems. The 2.0 Ha car park requires 160m2 of bioretention systems to meet targets. These systems are designed linearly to fit between car parks. Arrangements can be designed to value the cemetery's heritage, by appropriately placing walkways and bioretention systems. Bioretention swales have an average depth of 500 to 800 mm, hence will not disturb burial sites. The treated stormwater can then be collected in the underground storage in Queen St for additional toilet water supply.

Stormwater collected from Queen and Therry Streets can be directed through bioretention systems, treating the stormwater before discharge to the drainage system. The bioretention systems require 100m2 and 25m2 respectively and can be designed to suit streetscape.

5.5 WSUD Performance

Stormwater treatment will meet best practice of 80 per cent TSS reduction, 45 per cent TN and TP reduction. Approximately 7.5 - 10 ML/year of potable mains water conservation is maximised by using appropriate water for toilet flushing and wash down.

Water sensitive urban design options for Queen Victoria Markets

Rainwater harvested from the QVM roof (2ha). Stormwater can be harvested from the car park (1.8 ha) following treatment in bioretention systems.

Underground storage for treated stormwater runoff from car park and sheds H & I, such as the 'Rocla' type systems (refer to www.invisiblestructures.com.au).

Rainwater used for toilet flushing in the Queen St toilet block

Bioretention systems treat stormwater by physical and biological processes as water infiltrates through the vegetated media. Potential exists for bioretention systems in carpark, Queen St and Therry St. Bioretention systems can be configured as cells, swales or tree planter gardens to suit application.

Wash down to sewer. Rainwater should be used to wash down highly polluted areas (Sheds A, B, H & I, meat & fish areas). Highly polluted areas contain high organic loads from food handling. This wash down should discharge to sewer. A bunded area around sheds A & B and H & I will minimise cross contamination with the stormwater network. The same method could be used for the new bin washdown area in the Franklin Street stores.

Gross pollutant traps are presently situated in Therry and Victoria Streets. They remove litter and large pollutants and can operate at high hydraulic loading. Regular maintenance is required to ensure effective operation. Their operation should be reviewed in the context of the site stormwater quality management.

Stormwater used for toilet flushing in the Queen St toilet block and wash down could be stored in a 600m3 Underground storage tank giving a 75 per cent reliability for potable water replacement. Further investigation will identify quantities of rainwater harvested for reuse in three additional toilet blocks.

Demand management strategies throughout site including water efficient fittings, toilets, low flow high pressure hoses, metered water taps and pressure reduction valves.

Bioretention system for QVM carpark

Currently the large open carpark captures stormwater runoff and discharges flow directly to conventional drainage systems

Bioretention system - Stormwater is filtered through a prescribed media (eg. sand) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system.

Filter media for the bioretention system can range from coarse gravel to a sand/organic mulch mix. Provision of a underdrain using a slotted pipe is essential for collection and conveyance of filtered stormwater to the receiving water.

Heritage concerns - QVM is the site of Melbourne's first cemetery with its extent shown in the figure above. Bioretention systems can be designed within an allowable excavation depth and preserve the cemetery. Opportunities exist to enhance the site to recognize the cemetery's presence. (source - Austral Archaeology: conservation policy for old Melbourne Cemetery reproduced as Figure 9 - Queen Victoria Market - Master plan 2003)

Bioretention systems can be constructed as cells or median swale. The bioretention systems can be designed without loss of existing car park spaces enhancing the car park aesthetically and functionally.

Porous Pavements An alternative to conventional road pavements - modular pavements cells with gaps between cells to allow infiltration of stormwater. These systems have the capacity to detain stormwater to allow it to infiltrate into the subsurface. Some pre-treatment of stormwater inflow by means of removal of gross pollutants, and coarse to medium size sediment is desirable to reduce the likelihood of clogging.

Bioretention system Queen, Therry and Elizabeth Streets

Bioretention planter boxes - Bioretention systems can be constructed to accommodate street trees. Trees are lowered with an impervious cover. Stormwater runoff is collected in the planter box where temporary ponding occurs. Water infiltrates through the media and is collected by a conventional drainage system.

Bioretention system - Stormwater is filtered through a prescribed media (eg. sand) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system.

Refer to fact sheet 3b for more information.

Queen St and Therry St - Opportunities exist for bioretention systems to be installed in Queen and Therry Streets to treat stormwater runoff. Required treatment is dependent on the road catchment area to be treated.

Elizabeth St - Bioretention systems can be constructed to treat further stormwater in Elizabeth St before discharge to the Yarra River. Configurations can be creative and flexible to enhance the streetscape including tree planters, cascading gardens and swales. High flows will be accommodated by conventional drainage infrastructure.

Elizabeth St was the site of 'Williams Creek' or 'Townend River' before urban development. WSUD could include a river theme recognising Melbourne's past river in a revitalised streetscape.

Bioretention planters - section

Bioretention systems can be configured as cells or gardens to suit the streetscape. Both systems operate on similar principles that include infiltrating stormwater through a prescribed medium with dense vegetation. Both also includetemporary water retention to maximise the volume treated.

6 Ryder Oval Pavilion, Royal Park

This case study applies to a sports pavilion owned and operated by the City of Melbourne. The WSUD ideas expressed below have not been implemented in full at the pavilion. Two rainwater tanks have been installed; however they are not connected to the hot water system. The ideas for greywater reuse have not been implemented at the site. The WSUD initiatives in this case study are now considered in the pre-planning for all renovation works on pavilions in the City of Melbourne.

6.1 Nature of the development

Sporting amenities are being replaced for Ryder, Ransford and McAlister ovals in Royal Park. The planned building includes the installation of new change rooms, shower blocks and toilets. The amenities block caters for sporting teams for three ovals. These facilities are used by the sporting teams year round. They have a high usage with sporting events held on weekends and training throughout the week.

6.2 WSUD objectives

* *Total Watermark 2004* targets a 35 per cent potable mains water reduction for all council buildings and 40 per cent potable mains water reduction for all parks and gardens in the City of Melbourne.
* treat stormwater runoff to meet state guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and 70 per cent reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

6.3 Site constraints

The sporting amenities are used sporadically and intensively. The peak water demands occur during winter for weekends and evenings mirroring use; sporting matches and training sessions. Water usage is primarily for showering and toilet flushing with a similar sporadic demand. Park irrigation peaks during summer periods when fewer people are using the amenities.

6.4 Opportunities of WSUD

The current water usages within the sites are showering, toilet and urinal flushing, and hand basin and potable (drinking) water consumption. Potable (drinking water) must be used for hand basin and cold shower water supply. Rainwater can be captured from the amenity block's roof providing a resource for either toilet flushing or hot water. In this situation there is a high shower usage expected and hence a high 'light' greywater source. The light greywater can be treated and reused for toilet flushing. These options are explored in more detail below assuming 100 people per day used the amenities (as provided by Melbourne City Council). Average toilet demand is approximately 400 L/day and hot water demand is 2000L/day *12.

Option 1

The building provides a 386m2 catchment for harvesting rainwater. Considering rainwater use for toilet flushing and referring to the rainwater tank sizing curves for a 103L demand per 100m2 roof area *13 (refer to fact sheet 2a), a 7.5kL tank (i.e. 2 per cent of the roof area) will provide an 80 per cent supply reliability. Secondly, considering supplying hot water from rainwater is limited by available catchment. The large hot water demand (2000 L/day) compared to available catchment (386m2) limits feasibility of this option and hence is inappropriate.

Option 2

The amenities block produces a high volume of light greywater from showers that can be treated and reused. Assuming 80 showers per day, an average 4000L/day of light greywater will be produced. Appropriate uses for this greywater are toilet flushing and excess used for irrigation. The higher supply reliability (100 per cent) increases potable mains water savings for toilet flushing with additional savings from garden irrigation. Currently the ovals are not irrigated, with potential irrigation requirements to change in the future.

Light greywater contains contaminants and is unfit for human consumption. Typically these contaminants are low levels of bacteria, faecal matter, organic matter, micro-organisms and detergents. Care must be taken to limit human exposure to greywater (i.e. a closed system is required) and thus treatment is required.

Technology selection is dependent on desired water quality, footprint available and the overall treatment train. A subsurface wetland is appropriate to treat the light greywater for this application, requiring approximately 40 m2 with ample space in Royal Park to accommodate the wetland. Greywater will require further disinfection, such as UV or chlorine disinfection (refer to fact sheet 5f). Finally the storage tank provides a reservoir to meet public facility demand that varies over a typical day to supply. A header tank is required to provide sufficient pressure and storage for demand.

Stormwater treatment is required if rainwater is not harvested. For example bioretention systems (3m2) will provide sufficient treatment to meet best practice.

6.5 WSUD Performance

The water reuse options are summarised in Table 2. Greater potable mains water savings are attained by a greywater reuse scheme. Potential exists for irrigation to be supplied by this project and hence alters outcome though planning must also consider larger scale projects such as the wetland project in Royal Park.

Table 2.

Options available for water reuse

	Water source	**Water use**	**Potable mains water saving**
Option 1	Rain water	Toilet flushing	117 kL/year
Option 2	Light grey water	Toilet flushing and irrigation	146 kL/year for toilet flushing + irrigation

Stormwater runoff will be treated to meet Victorian best practice (80% reduction of TSS and 45 per cent TN and TP reduction), noting that harvested rainwater reduced potential runoff water and hence required treatment.

Ryder Oval amenities - water sensitive urban design options

OPTION 2 - Greywater treatment - light greywater (shower water) can be collected, treated and reused. Shower water can be directed to a subsurface flow wetland. Separate plumbing is required to separate shower water from toilet wastewater.

Irrigation - greywater can be used for garden irrigation in Royal Park and the immediate vicinity of Ryder Oval.

Stormwater treatment - If not collected, roof runoff should be treated for example using a bioretention system to meet Victorian best practice.

Greywater treatment process

The mesh screen physically removes larger objects from the process. The separator removes fats, oils and grease. The subsurface flow wetland has the dual purpose regulating 'in' flow and water treatment. Sedimentation removes larger sized pollutant and dissolved organic matter is reduced by the biological treatment. Organic material if unremoved can cause the greywater to discolour, become anaerobic and give off odours. The wetland is very effective in removal of pathogens.

OPTION 1 - Rainwater harvesting - collect roof runoff and use for toilet flushing. A 7.5 kL tank will provide an 80 per cent supply reliability for toilet flushing.

A first flush device should be installed to divert the first 1-2 mm rainfall thereby removing debris and pollutant load. Screens and meshes should be installed on the tank's inlets and outlets roof gutters to prevent debris collection and mosquitos.

Cross Section Detail of Vertical Upflow Subsurface Wetland

Subsurface wetlands

Subsurface wetlands are a proven technology to adequately remove organic matter and suspended solids. In subsurface flow wetlands all the flow is through the soil substrata. The soil typically has a high permeability and contains gravel and coarse sand. The bed is planted out with appropriate vegetation. As the flow percolates through the wetland BOD and TSS are predominately removed by biological decomposition. Refer to fact sheet 10 for more information.

Approval

EPA Victoria and Council approval is required for greywater systems greater than 5000L/day. For systems less than 5000 L/day, Council approval is required for EPA certified systems.

The Department of Human Services has also prepared guidelines for the greywater reuse, available from their website (www.health.vic.gov.au/environment/).

Maintenance

Adequate provision for downtime, such as scheduled maintenance, is required. As such the treatment system should incorporate a bypass to sewer.

The wetland requires weeding and typical landscape maintenance. During the establishment phase, additional maintenance is required to ensure correct vegetation growth.

Refer to the City of Melbourne's WSUD document for additional direction.

7 Dynon Rd Canal

This case study provides a WSUD alternative for treating a polluted tidal canal in West Melbourne. Not yet implemented, the design is fully supported by the City of Melbourne and funding for the project is currently being sought. It is intended the project will be implemented in the coming years.

7.1 Nature of the development

The Dynon Rd Canal is a 1km unlined open-channel drain that runs along the south side of Dynon Rd in West Melbourne. Through a combination of inadequate hydraulic capacity, pollution and weed infestation the canal has

caused significant concern to Council and the general community including concerns of:
* odours;
* algal blooms;
* poor visual amenity; and
* flooding.

The key water quality issues are a result of the combination of urban stormwater pollution and poor hydraulic efficiency of the canal leading to the deposition of litter, sediment and hydrocarbons. The impact of these pollutants are exacerbated by the flat slope of the canal which results in stagnant pools of water. High organic load discharged into the canal reduces the dissolved oxygen in the water leading to the frequent and extended periods of water in a state of anaerobic conditions.

7.2 WSUD objectives

The WSUD objectives aim to improve water quality, prevent stagnant water and improve aquatic and riparian habitat. Improving hydraulic conductivity will increase the canal flowrate and therefore minimises flooding risk. Stormwater quality aims to meet best practice pollutant load reduction targets:
* total suspended solids - 80 per cent reduction in the average annual load;
* total phosphorous (TP) and total nitrogen (TN) - 45 per cent reduction in the average annual load;
* litter - 70 per cent reduction in the average annual load.

7.3 Site constraints

Dynon Road Canal is an existing stormwater drain, with the retrofitting project constrained by:
* shallow water table (up to 0.9m Australian Height Datum (AHD)) (groundwater will enter canal if its surface is lower than the surrounding water table);
* the deep invert levels of stormwater pipes. Stormwater discharges directly into the conventional drainage system from the canal's northern side (down to 0.2m AHD);
* naturally occurring Coode Island silts (which has the potential for acid generation if exposed to air) at a depth of approximately 0.5m AHD; and
* limited area for treatment for the surrounding catchment.

7.4 WSUD opportunities

The proposed design is based on two core principles:
* rehabilitating the existing canal into two linear ephemeral wetland systems to treat stormwater; and
* ensuring that provision is made to drain the ephemeral wetland so that no standing water is present.

Sections of the ephemeral wetland in the vicinity of major stormwater outfalls will be configured to provide sediment and gross pollutant removal.

Stormwater will be subjected to temporary detention in the wetlands controlled by a riser outlet structure. Treated stormwater will be discharged into a new stormwater pipe, and then to a pumping station. Flows in excess of the storage capacity of the ephemeral wetland will overflow directly into the underground pipe. Topsoil would be added to the canal and it would be planted with ephemeral wetland plants while preserving as much as possible the remnant vegetation. The ephemeral wetlands will also provide additional flood storage during large flood events.

The existing canal bed will be capped to contain existing contaminated silt. The base of the wetland will be set at 1.0m AHD to avoid groundwater intrusion and/or exposure of Coode Island Silts. The majority of the stormwater pipe inverts from the north of Dynon Rd are lower than the wetland base as so will be connected directly to the new stormwater pipe rather than to the wetland.

In addition to the riser outlet structure, a perforated pipe surrounded by a sand layer underlying the existing canal would be employed to ensure that the linear wetlands are completely drained during dry periods thus not leaving any localized pools of shallow standing water.

7.5 WSUD Performance

The table below shows the expected water quality outcome for the wetland based on MUSIC modeling.

Pollutant	Total Suspended Solids	Test Phosphorus	Total Nitrogen
Pollutant Removal	66%	53%	33%

The hydrologic effectiveness is 67 per cent, that is the percentage of mean annual runoff volume from catchments draining into the wetland that is treated by the wetland. This represents the maximum catchment treatment within the available area.

8 Dodds St - streetscape renewal

This case study has not yet been implemented. It outlines WSUD initiatives that can be applied to a streetscape. Discussions have been held with partners, and funding is being sought to implement the project in the coming years.

8.1 Nature of the development

Dodd St is situated behind the Victoria College of the Arts, with the section between Southbank Boulevard and Grant Street being upgraded. This upgrade represents a contemporary streetscape renewal. The traffic is predominately pedestrian with the streetscape being redesigned to block through road traffic. An open pedestrian area is planned with contemporary streetscape landscaping. The open space is adjacent to the Drama Theatre and provides oportunities for community activities, such as open air dances.

A river theme has been suggested for the street. Flowing lines and forms, water and integrated stormwater treatments are indicative of a river complementing the streetscape theme.

Limited vehicular traffic access is required for the college's buildings to cater for the Arts centre diverse activities. Traffic is expected to be infrequent, though there is potential for large vehicles for deliveries.

8.2 WSUD objectives

* *Total Watermark 2004* targets an absolute 40 per cent potable mains water reduction for council parks and gardens sites *14.
* treat stormwater runoff to meet state guidelines, specifically 80 per cent reduction of total suspended solids (TSS), 45 per cent reduction of total phosphorous (TP) and total nitrogen (TN) and 70 per cent reduction in litter entering stormwater from the site. Thereby reducing pollutant loads to the stormwater systems and Port Philip Bay.

8.3 Site constraints

Provision for an open public space is required by the Victorian College of the Arts, with an open area adjacent to the drama school desirable to hold outdoor dances and performances. Streetscape is designed to conform to modern requirements for public open space and footpath widening.

Vehicular traffic access is required for the Victorian College of the Arts.

8.4 Opportunities of WSUD

Opportunities exist for roof runoff capture and reuse. Currently roof runoff flows onto the street from buildings lining both sides. Presently the downpipes from the police stables, VCA Gallery, School of Art, VCA secondary school and the building designated as possible future studio space run into Dodd St. Installation of a new gutter to collect roof runoff is required. The gutter can run along the top of the building, flowing into a storage tank.

Roof runoff requires minimal treatment for reuse, provided a first flush device is installed. The rainwater provides an excellent resource for police stables. Water is used in the adjacent police stables for horses and the wash down of horses and stables. Opportunities exist for roof runoff to be used in the VCA secondary school for toilet flushing.

Planned buildings, such as the Yarra Arts Centre, should incorporate WSUD into their design, managing and treating their stormwater onsite. Roof runoff can be used appropriately such as for toilet flushing or garden irrigation.

Stormwater runoff will be captured from the street and treated, through a constructed linear wetland, which will complement the river landscape theme. An arch shape around the open space will define the performance area. The wetland can be lined with benches to provide sitting and a barrier to the wetland. A bridge over the wetland near the college will allow traffic access and contribute the river theme. This WSUD element, the free flow surface wetland, will enhance the streetscape river theme.

The free surface wetland will remove suspended solids and nutrients will require a surface area of 120 m2 to treat the 3000 m2 impervious upstream catchment to best practice (refer to fact sheet 4b). Additional wetland area will be required if runoff from the adjacent buildings are to be treated. The wetland will follow the natural water course and slope, flowing from Southbank Boulevard to Grant St, with runoff entering the wetland closest to the Southbank Boulevard. This requires Dodd St to be sloped towards the wetland entrance. Additional entrance points can be located along the wetland, though this decreases the treatment effectiveness.

The wetland will consist of a vegetated reed bed with a permanent pool depth of 100mm. The free surface flow wetland will have a gravel base to support the vegetation and biofilm growth. Biological processes in the wetland assist in nutrient removal. Vegetation also assists flow management by reducing water velocity thereby encouraging sedimentation.

High flows will be accommodated by directing overflow directly to the conventional stormwater drainage.

At the Grant St end of Dodd St, insufficient wetland treatment is available. Stormwater runoff from this area will be treated in bioretention systems. Bioretention systems will be designed to suit landscaping requirements such as a tree planter or a garden bed configuration considering the small catchment area to be treated.

Treated stormwater from the wetland and bioretention systems provide additional opportunities for water reuse include the irrigation of public open space areas such as the park in Grant St.

8.5 WSUD Performance

Stormwater runoff will be treated to meet Victorian best practice (80 per cent reduction of TSS and 45 per cent TN and TP reduction). Potable mains water consumption will be reduced by supplementing irrigation water and rainwater use in the police stables.

Dodds St - water sensitive urban design options

Bioretention system

Stormwater runoff at Grant St end treated in bioretention cell with configuration designed to suit streetscape design.

Constructed wetland

A constructed wetland will treat captured stormwater runoff from Dodds St. The wetland can be configured linearly along the length of the street and constructed with hard edges for a contemporary streetscape. Constructed surface wetland systems use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. Refer to fact sheet 4b for more information.

Streetscape renewal

A constructed wetland will treat captured stormwater runoff from Dodds St. The wetland can be constructed with hard edges for a contemporary streetscape.

Garden irrigation

Public open space in Grant St can be watered by treated stormwater from Dodds St wetland.

Rainwater harvesting

Capturing roof runoff from Police stables and Dodds St buildings thereby minimising stormwater runoff and discharge. Roof runoff could be used for horses and washing down stables.

Constructed wetland with hard edges

Wetland processes

The wetland processes are engaged by slowly passing runoff through heavily vegetated areas where plants filter sediments and pollutants from the water. Biofilms that grow on the plants can absorb nutrients and other associated contaminants.

Inlet zone

The wetland inlet zone (or sediment basin) is designed to regulate flows into the macrophyte zone and remove coarse sediments. The inlet zone also enables a bypass pathway to be engaged once the macrophyte zone has reached its operating capacity.

Macrophyte zone

An important operating characteristic of macrophyte zones is even, well distributed flows that pass through various bands of vegetation. Strong vegetation growth is required to perform the filtration process as well as withstand flows through the system. Vegetation selection is heavily dependant on the regional climate. Flow and water level variations and maximum velocities are important considerations and can be controlled with an appropriate outlet structure.

Wetland maintenance

Sediment basins requires maintenance every two - five years to remove coarse sediments. The wetland requires weeding and typical landscape maintenance. During the establishment phase, additional maintenance is required to ensure correct vegetation growth.

Public open space - a dance area is required in front of the Drama theatre. The wetland can be designed to define the public open space area.

Hard edges can be used with constructed wetlands to suit contemporary landscape.

River theme - the streetscape can be configured ton include a river theme.

Section Three

Water Sensitive Urban Design (WSUD) Fact Sheets

Introduction

The City of Melbourne's WSUD Guidelines provide guiding principles and potential scenarios for water sensitive urban design application. This final section provides the technical details.

WSUD technologies are broadly grouped into 'low technology' (Fact Sheets One to Four) and 'high technology' (Fact Sheets Five).

The main characteristics for each WSUD element are summarised in Table One.

Towards high quality waterways

As explained in section one, WSUD is about improving waterway health and reducing consumption of potable water resources. Waterway rehabilitation reduces pollutants in creeks, rivers and bays through mimicking natural waterway systems. Vegetation selection, stabilisation of the waterway, adequate flood conveyance and an appropriate hydrologic regime all need to be considered.

Waterways including Port Phillip Bay, the Yarra River, the Maribyrnong River and Moonee Ponds Creek are popular recreation areas for our communities. Improved waterways help promote appreciation of our natural environment and its ecological value. Improved waterways can also improve property values of surrounding areas.

In the City of Melbourne, the hydrologic regime of waterways has been drastically changed through straightening, widening, bank stability and infrastructure development, and is beyond the point of returning to pre-urbanisation conditions. A realistic approach for rehabilitated waterways would be to use existing hydrologic conditions more effectively. Waterways need to be stable from erosion, provide habitat for aquatic and terrestrial species, and enhance the urban and natural environments.

To protect waterways, upstream run-off needs strategies to reduce pollutants. Litter, debris and coarse sediments all impact the aesthetics of a waterway, and poison habitats, generate odours, attract pests and deposit dangerous pollutants.

Table 1

WSUD elements, their fact sheet number and key selection characteristics

Fact sheet	Key characteristics	Pollutant separation by physical process	Pollutant removal by biological treatment	Designed for water flow (conveyance)	Water retention	Urban Design Qualities
1	Wise water use	-	-	-	-	-
2	Rainwater tanks	Primary purpose.	Does not contribute.	Does not contribute.	Primary purpose	Does not contribute
3a	Vegetated swales and buffer strips	Primary purpose.	Some impact but not primary purpose.	Primary purpose.	Does not contribute.	Primary purpose.
3b	Bioretention systems (swales and basin)	Primary purpose.	Primary purpose.	Primary purpose. (swale)	Some impact but not primary purpose.	Primary purpose.
3c	Sedimentation (settling)	Primary purpose.	Does not contribute.	Does not contribute.	Primary purpose	Some impact but not primary purpose.
3d	Gross pollutant trap	Primary purpose.	Does not contribute.	Does not contribute.	Does not contribute.	Does not contribute.
4a	Subsurface flow wetlands	Primary purpose.	Primary purpose	Does not contribute.	Some impact but not primary purpose.	Primary purpose.
4b	Free surface flow wetlands	Primary purpose.	Primary purpose	Does not contribute.	Some impact but	Primary purpose.

					not primary purpose.	
4c	Ponds and lakes	Primary purpose.	Some impact but not primary purpose.	Does not contribute.	Some impact but not primary purpose.	Primary purpose.
5a	Suspended growth biological processes	Does not contribute.	Primary purpose.	Does not contribute.	Does not contribute.	Does not contribute.
5b	Fixed growth biological processes	Does not contribute.	Primary purpose.	Does not contribute.	Does not contribute.	Does not contribute.
5c	Biological filter	Does not contribute.	Primary purpose	Does not contribute.	Does not contribute.	Does not contribute.
5d	Depth filtration	Primary purpose	Does not contribute.	Does not contribute.	Does not contribute.	Does not contribute.
5e	Membrane filtration	Primary purpose	Does not contribute.	Does not contribute.	Does not contribute.	Does not contribute.
5f	Disinfection	Does not contribute.	Primary purpose	Does not contribute.	Does not contribute.	Does not contribute.

Elements discussed in this section cover a wide variety of applications on different scales.

The three main scales on which WSUD elements can be employed are:
* site (run-off from single sites);
* precinct (groups of houses or streetscapes); and
* regional (involving larger catchment areas).

Fact Sheet 1:

Wise water use

Typical application scale: site, precinct, regional

Supplying drinking water to Melbourne is an increasing challenge. A growing population, environmental flow demands, and the potential of reduced rainfall influenced by climate change all play a part. Australia is the world's driest inhabited continent, and Australians are one of the highest per capita users of water. Clearly, it is vital that everyone in Australia improves the way precious water reserves are used.

Demand Management

No matter where water comes from, significant savings can be made by using it more effectively. Demand management, or managing your demand for water, can be achieved by changing our wasteful habits and by fitting water efficient devices. Information and incentives related to improving water efficiency in your home, workplace or industry is available from the City of Melbourne, City West Water and South East Water.

People in the City of Melbourne have traditionally used water inefficiently and sometimes wastefully. The National Water Conservation Labelling Scheme was recently developed for water appliances such as shower-heads, washing machines, toilets and dishwashers, to help increase the purchase of water-efficient devices. The more water efficient a product is, the more 'As' on the label. AAA is the minimum requirement for a water-efficient product. AAAAA is the maximum, awarded to the best-performing products, including super waterefficient dishwashers and washing machines.

By switching to AAA (or better) rated appliances, and changing behaviour, it is possible to reduce water consumption by 15 per cent. When working to reduce water consumption, check your solution won't inadvertently increase your energy use.

Demand management is especially important in garden design. Plant selection and zoning of vegetation types can also reduce water demands considerably.

Water efficiency ratings assess the water use of appliances. By requiring AAA or better, up to 15 per cent of potable water demand can be reduced

Education on matters such as tap maintenance can save potable water supplies

Water efficient gardens, using Indigenous vegetation, can vastly reduce irrigation.

Using alternative water sources

Reducing potable water demand means finding alternative sources of water. How water is used can determine the appropriate quality - and source - of water. Most domestic, commercial and industrial water does not need to be of drinking

standard, so it is possible to supply water from different sources. Some alternative water supply sources are:
* using roof run-off/rainwater tanks;
* reusing greywater (from laundry and bathroom);
* reclaiming water (from local wastewater treatment plants); and
* recycling plant water (at an industrial premise).

To determine an appropriate source of water for reuse, the following issues require consideration:
* availability of the alternative source;
* proximity to the use;
* infrastructure requirements;
* risk of cross connections (health impacts);
* method of treatment required to achieve quality appropriate for reuse;
* occupant behaviour and attitude; and
* other environmental objectives such as energy efficiency and greenhouse emissions.

A hierarchy of options for water reuse, grading from the easiest to implement to the most extensive water reuse options is presented below. Choosing the best option for a development will depend on the scale of the development, the proximity to treatment facilities and the importance of reducing water consumption.

The recommended hierarchy for household reuse options is:
* rainwater reuse for toilet and garden;
* rainwater for hot water, household greywater for garden and toilet;
* reclaimed (recycled) water to toilet and garden, rainwater for hot water.

Further information

Don't forget you can call the Green Plumbers for great water saving assistance in the household on 1800 133 871 or check them out on www.greenplumbers.com.au And for great advice for the garden, visit a nursery that is accredited with Sustainable Gardening Australia www.sgaonline.org.au

Fact Sheet 2a:

General rainwater tank information

Typical application scale: site and precinct

Tank design

With good planning, rainwater storage tanks can be incorporated into new or existing building designs so they don't impact on the aesthetics of the building or streetscape. Tanks can be selected to suit heritage areas, they can be located underground and some newer slimline designs incorporate tanks into fence or wall elements.

Tank sizing

Tanks are sized to meet the intended use for the water and available roof area for collecting rain. Fact Sheets 2a and 2b will help you select the right tank size, based on your intended use, roof catchment area and rainfall characteristics for Melbourne. Well-designed houses fitted with an appropriate tank can potentially reduce demands on potable water supply by using rainwater for toilet flushing and in hot water systems. To get a clear picture of where you use water around the household, try using the City of Melbourne hardcopy water calculator found at http://www.melbourne.vic.gov.au/info.cfm?top=120&pg=1136

Figures One to Three use Melbourne rainfall characteristics data, including frequency of rain and quantity, and assume typical demand values from AAA rated appliances. The curves allow you to calculate tank size relative to the roof area occupancy rate and preferred reliability of supply. Generally, rainwater systems become unfeasible if roof areas are less than 15m2 per person or a supply reliability of 75 per cent is not achievable.

If the water demand (or occupancy) and roof areas are known, a tank can be selected using Figure One. Practical tank size can be assessed by evaluating the reliability of supply (the percentage of demand that will be supplied by the tank). Only marginal gain is attained by installing a tank larger than approximately two to four per cent of roof area (dependent on demand). In these situations the increased tank size and cost must be evaluated against additional potable water conservation strategies. See Fact Sheet 2b for a worked example. An inner city residential tank will usually be 1.5 to 3 kL, depending on roof area and water use. When household or workplace supply can't be met by rainwater stored in the tank, the shortfall is usually provided through main-supplied potable water using appropriate connections. Integrated management systems and technology can automate rainwater use throughout the household.

Tank installation

Rainwater tanks should be fitted with 'first flush diverters'. These are simple mechanical devices that divert the first portion of rainwater run-off so that debris and contaminants from gutters and roof area do not enter the tank. After the first flush diversion, water feeds directly into the tank.

Collected roof run-off water is suitable for use in garden irrigation and toilet flushing with no additional treatment. Tank water can also be used in hot water systems, subject to City of Melbourne approval, although some additional treatment to remove the risk of contamination may be needed. Safe treatment can usually be achieved by ensuring that the hot water service maintains a temperature of at least 60 to 70 degrees C. Installation of a UV disinfection unit can also provide treatment. A licensed plumber is required to install a rainwater tank with all installations conforming to Australian standards (AS3500.1.2 Water Supply: Acceptable Solutions)1.

City of Melbourne planning approval

Installation of tanks within Heritage Overlay areas and tanks larger than 4,500 litres in the City of Melbourne municipality require a planning permit. Tanks outside Heritage Overlay areas, and smaller than 4,500 litres, have Victorian Government exemption (Clause 62.02 of the Victorian Planning Provisions). The City of Melbourne can advise on exemptions and planning permit requirements.

Due to the heritage nature of the City of Melbourne, most properties must lodge a planning permit for a rainwater tank. For works less than $10,000 on a single dwelling on a lot, there is no fee for a planning permit. The planning permit only needs to address issues relating to heritage, primarily, whether the tank can be seen from streets or laneways, and its effect on existing building fabric.

Buildings listed on the Victorian Heritage Register will require a Heritage Victoria permit under the Heritage Act 1995. Once approved, a planning permit is not required.

For rainwater tanks installed within the building fabric, such as in a roof space, under raised floors or in the upper floors of an apartment building, a building permit may be required. The weight of a water tank can impact on a building's structure, and a building permit is needed to address this issue. The City of Melbourne can provide further advice.

Fact sheet 2b:

Rainwater tanks for the household

Typical application scale: site and precinct

Rainfall patterns (how often it rains), and rainfall intensity (how hard it rains), influence the effectiveness of installing a rainwater tank. Rainwater tank size is dependent on:
* your roof area; and
* what collected water is to be used for.

The tank sizing curves below (Figures Two and Three) consider the collection of water for toilet flushing and outdoor irrigation, taking the typical City of Melbourne household, and climate, into consideration. They have been developed using a software program called MUSIC that uses historical rainfall data for Melbourne. Water uses are either constant (like toilet flushing) or seasonal (like garden watering). More water is used in gardens in the summer, and the 'outdoor use curve' accommodates this variation. Connecting the rainwater tank to the toilet is preferable as the flushing creates a constant yearly demand and hence maximises the use of the tank volume.

Steps to calculate appropriate sized tank:
1. Calculate the roof area (m2) available for catching rain.
2. Decide whether you will use the water for toilet flushing or for the garden.
3. Refer to the appropriate curve:
a. Toilet flushing (Figure Two) - calculate how many people per 100m2 of roof area. Then read off the supply reliability for desired tank size;
b. Outdoor use (Figure Three) - calculate the garden area that you water. Then determine garden area per 100 metres of roof area. Then read off the supply reliability for desired tank size.

Typical household example - TOILET FLUSHING (Figure 2)
How to calculate rainwater needed for toilet flushing in a four-person household.
Roof area = 250 m2.
First, convert the number of people to a standard basis (per 100m2 roof area).
Four people per 250 m2 = 1.6 people per 100m2.
(250/100 = 2.5 therefore 4/2.5 = 1.6).
Second, use the toilet flushing tank sizing curve to achieve 90 per cent reliability.
This shows that a tank size of approx. 1.0 per cent of the roof area (250m2) is needed.
((250 x 1 per cent) x 1 metre (depth) = 2.5 m3). 2.5 m3 equals 2.5 kilolitres (2,500 litres).
So, on average, a 2,500 litre rainwater tank will supply 90 per cent of toilet

flushing requirements for this household.

Typical household example - OUTDOOR USE (Figure 3)
How to calculate rainwater needed for garden watering. The garden area is 250 m2 but only 187.5m2 is watered.
Roof area = 250 m2.
First, convert the roof area to a standard basis of 100m2 (250/100 = 2.5).
Likewise convert the watered garden area by the same factor.
187.5/2.5 = 75 m2 garden area per 100m2.
Second, use the outdoor tank sizing curve to achieve 50 per cent reliability.
This shows that a tank size of approximately 1.35 per cent of the roof area (250m2) is needed.
250 x 1.35% = 3.375 m3.
3.375 m3 equals 3.375 kilolitres (3,375 litres).
So, on average, a 3,375 litre rainwater tank will supply 50% of outdoor watering requirements for this household.

To size a tank to supply both water demands, toilet flushing and outdoor use, add 3,375 litres to 2,500 litres. The required tank size becomes 5,875 litres.

Fact Sheet 3a:

Vegetated swales and buffer strips

Typical application scale: site, precinct and regional

Swales

In certain locations, vegetated swales can replace pipes in conveying stormwater. Swales are beneficial in providing a 'buffer' between the receiving water (for example, Port Philip Bay, a river, or wetlands) and the impervious areas of a catchment (such as roads and roofs). Swales work by interacting and slowing stormwater as it passes through an area. This control of flow means pollutants can settle in the vegetation. Total nitrogen (TN) is generally the nutrient pollutant in swale systems that limits design effectiveness, as it is the most difficult to remove. Swales can be incorporated in street designs, parks and gardens and add to the character of an area.

To convey flood flows, in excess of the treatment design flow, pits draining to underground pipes can be incorporated. In these situations, water is allowed to overflow from the swale into a discharge pit.

The longitudinal slope of a swale is an important consideration. They generally operate best with slopes from two per cent to four per cent. Slopes less than this can become waterlogged, or form stagnant ponds. Under-drains can alleviate this problem if a flatter grade can't be avoided. For gradients greater than four per cent, 'check banks' along swales, dense vegetation and/or drop structures can help to distribute flows evenly across the swales, and slow velocities to minimise erosion.

Selection issues

Road or driveway crossovers are an important consideration in design. Driveway crossovers can be used as 'check dams' (temporary water collection points), or can be constructed at grade, to act like a ford during high flows.

A variety of vegetation types can be used in swales. Vegetation should cover the whole width of the swale, be capable of withstanding design flows and be of sufficient density to provide good filtration. Compatibility with the landscape of the area, and maintenance capabilities, are also important considerations. For best performance, vegetation height should be above the designed treatment flow water level. Maintenance is typical of landscaping, with vegetation growth the key objective. Here are some examples:

Swales are often limited by TN reduction. Sizing curves therefore use TN reduction as their basis. Figures Four and Five show curves for Melbourne. The sizing curves relate the swales performance to a percentage of the impervious catchment area to be treated. They relate the vegetation height (Figure Four) and the swale slope (Figure Five) to the TN removal. Note the sizing curves are used to assess the top width of the vegetated swale.

Buffer strips

Buffer strips provide discontinuity between impervious surfaces and the drainage system. Like swales, buffer strips provide an even shallow flow over a wide vegetated area. Buffers are commonly used as a pre-treatment for other stormwater measures.

Buffer strips should be set down lower than the road surface, allowing for sediment accumulation over time. The set down required is a trade-off between creating scour, which leads to erosion problems from run-off, and providing sufficient build-up space for accumulated sediment. Generally, between 40mm and 50mm set down from the paved surface is enough, with a pavement surface that tapers towards the buffer strip (as illustrated in the Figure Six).

For detailed information, refer to Chapter Eight of Melbourne Water's *Draft Technical Manual WSUD Engineering Procedures: Stormwater.*

Fact Sheet 3b:

Bioretention systems

Typical application scale: site and precinct

Bioretention systems filter stormwater run-off through a vegetated soil media layer. Water is then collected through perforated pipes, flowing to downstream waterways or to storage for reuse. Temporary water pools above the soil media provide additional treatment, allowing pollutants to settle. Bioretention systems are not intended to be infiltration systems. The main method for stormwater dispersal is not via soaking into the ground to replenish groundwater flows. Any loss in run-off is predominantly attributed to maintaining filter media moisture, which is also the vegetation's growing media.

Vegetation that grows in the filter media enhances its function by:
* preventing erosion of the filter medium;
* continuously breaking up the soil through plant growth to prevent clogging of the system; and
* providing biofilms on plant roots that pollutants can adsorb to.

Selecting appropriate filtration media means balancing the provision of sufficient hydraulic flow to push water quickly through the filtration, with the retention of enough water to support vegetation growth. Typically, a sandy loam type material is suitable. However, soils can be tailored to particular vegetation types and treatments requirements.

Application and design of bioretention systems are typically limited by their capacity to remove total suspended solids (TSS). Figure Eight presents a design curve for preliminary sizing of a bioretention system in Melbourne. It relates typical performance to a percentage of the impervious catchment.

Bioretention basins

The treatment process in bioretention basins is similar to bioretention swales. Typically, flood flows bypass the basin, preventing high flow velocities that can dislodge collected pollutants and scour vegetation. Bioretention devices can be installed at various scales, for example, in planter boxes, in retarding basins or in streetscapes integrated with traffic calming measures.

Swale bioretention system

Swale bioretention systems (refer to Figure Seven) provide both stormwater treatment and conveyance functions. A bioretention system is installed in the swale's base. The swale component provides stormwater pre-treatment to remove coarse to medium sediments while the bioretention system removes finer particulates and associated contaminants.

A bioretention system can be installed in part of a swale, or along the full length of a swale, depending on treatment requirements. Typically, these systems should be installed with slopes of between one per cent and four per cent. In steeper areas, 'check dams' are required to reduce flow velocities. For milder slopes, adequate drainage is needed to avoid nuisance water-pooling. A bioretention system along the full length of the swale can provide necessary drainage.

Run-off can be directed into conveyance bioretention systems either through direct surface run-off, using flush kerbs, or from an outlet of a pipe system.

Fact Sheet 3c:

Sedimentation (settling)

Typical application scale: precinct and regional

Sedimentation removes pollutants from the water column by gravity settling. Reduced flow velocities are a necessary part of sedimentation, as slowing flow allows particles to settle. Typically, coarser particles are removed more easily than finer particles. Enhanced sedimentation processes allow finer particles to aggregate and then settle.

Sedimentation occurs in many water-sensitive urban design elements including:
* sedimentation basins;

* tanks (storage tanks, balancing tanks, rainwater tanks, stormwater tanks);
* ponds, lakes; and
* wetlands.

Each of these elements reduces flow velocity, increasing the retention time and decreasing turbulence, allowing settling to occur.

Design considerations

The key design parameters are the sediment's terminal settling velocity (primarily dependent on shape and density) and hydraulic conditions (water velocity and retention time). The sediment separation device can then be sized. Sedimentation systems generally target coarser particles. Finer pollutants require additional treatment due to more complex interactions. In the case of finer pollutants, their size, shape, structure and charge have a greater influence on removal.

Sediment basins

Sediment basins are typically incorporated into pond or wetland designs. The 'exclamation mark' wetland at the National Australia Bank forecourt at Docklands is a good example in Melbourne. Sediment basins can drain during periods without rainfall and then fill during run-off events. They are frequently used during construction activities and as pre-treatment for elements such as wetlands, including inlet ponds. Sediment basins are sized according to the design storm discharge and the recommended target particle size is 0.125mm.

The large quantity of coarse sediment carried in stormwater requires regular removal from the basin. Coarse sediments generally have low contaminant concentrations and should be kept separate from the fine sediments. Fine sediments normally contain the highest concentrations of contaminants, including hydrocarbons and metals, therefore incurring higher waste disposal costs. Sediment basins are designed to retain predominantly the coarse sediment fraction.

Maintenance of sediment basins is required every two to five years, depending on the catchment. Maintenance can include draining the basin and excavating collected sediments for landfill. To drain, smaller basins can be pumped, while larger basins should have an under-drain. Construction sites that produce very large sediment loads, should be regularly de-silted. A sediment basin will generally require resetting after development if the catchment is complete.

Selection issues

The location of a sediment basin is determined by available space and suitable topography, although temporary 'turkey nest' basins can also be constructed. Outlet controls are important for the basin's extended detention function, as well as ensuring adequate settling time. Outlet structures should be designed for even detention times, for example typically a multiple level off-take riser will regulate flow to downstream wetland or pond.

Design issues

The depth of a sediment basin is usually set to minimise weed growth and to allow for adequate storage of collected sediments, usually a minimum of one metre. Detailed designs are available from Melbourne Water's Draft WSUD Engineering Procedures: Stormwater2.

Tanks, ponds and wetlands

Reduced flow velocities and still conditions can cause physical separation by sedimentation in tanks, ponds and wetlands. Fact Sheets 4a, 4b and 4c have more information.

Advanced sedimentation systems

More advanced sedimentation devices, including clarifiers, can be incorporated into blackwater, greywater and sewer mining treatment processes. These devices combine mechanical and physical design principles, used to enhance sedimentation with the main advantage being the reduced footprint required.

Fact Sheet 3d:

Gross pollutant traps (GPTs)

Typical application scale: precinct and regional

Gross Pollutant Traps (GPTs) are installed in the City of Melbourne to screen and trap litter and debris before it enters our waterways. Some GPTs also remove bed load sediments and some suspended sediments through rapid sedimentation. The City of Melbourne has installed ten GPTs, with a further four to be installed by 2008. Some gross pollutant traps have also been installed by private developers.

Gross Pollutant Traps are commonly used in conventional drainage systems, either in pipes, at outfalls or in open channels. They can also be used as pre-treatments for WSUD elements including the protection of rehabilitated waterways. They are designed to retain solid litter that has washed into the system, without retarding flows or increasing water levels in the drainage system. Many WSUD elements do not require a GPT (especially those with streetscape and source control measures buffering the stormwater drainage system from contributing areas), as the entry of litter and debris to the stormwater system is restricted by filtration media.

Unlike other WSUD elements, a wide range of commercial Gross Pollutant Trap products are available from more than 15 suppliers in Australia. Different GPTs employ different methods of litter separation and containment, and their performances can vary greatly. There are also GPTs designed for different catchment scales, from less than one hectare to more than 100 ha. Choose an appropriate GPT depending on site conditions. The City of Melbourne can give advice to private developers on the most appropriate GPT's for a site within the municipality.

Selection issues

Isolating areas that generate high pollutant loads is the key to locating a GPT. GPTs are primarily sized on hydraulic considerations, so the amount of 'clean' (gross pollutant free) water that is treated should be minimised. Gross Pollutant Traps are generally sized to treat three-month to one-year ARI peak flow, and work best with catchment areas less than 100 hectares. These design flow rates are based on treating more than 95 per cent of annual run-off volume.

Selecting a GPT means balancing the life-cycle costs of the trap (combining capital and ongoing costs), with expected pollutant removal performance. Water quality requirements of the downstream water body and any social considerations also need to be looked at.

A life-cycle cost approach that considers long-term operation costs, and the benefits of different traps assessed over a longer period, is recommended. The overall cost of GPTs is often determined by maintenance costs rather than capital costs.

Design issues

Regular maintenance of Gross Pollutant Traps is essential for their success. When installing a GPT, the City of Melbourne follows a maintenance program. It is expected developers will follow a maintenance program also. Cleaning at least every three months is usually a part of the maintenance program, but this can depend on the catchment characteristics and source reduction initiatives that are active in the area. A poorly-maintained GPT will not only fail to trap pollutants, but may release contaminants by leaching from the collected pollutants.

Fact sheet 4a:

Subsurface flow wetlands

Typical application scale: site and precinct

Wetlands are a complex assemblage of water, soils, microbes, plants, organic debris, and invertebrates. In subsurface flow wetlands. all the flow is through the soil substrata, as illustrated in Figure Nine. The soil usually has a high permeability and contains gravel and coarse sand. The bed is planted with appropriate vegetation. As flow percolates through the wetland, biological oxygen demand (BOD) and total suspended solids (TSS) are predominately removed by biological decomposition.

Subsurface wetlands are applied in wastewater and greywater treatment systems where there is a relatively consistent in-flow rate. In comparison, surface wetlands used to treat stormwater flows must be designed to cope with variations in flows as a result of rainfall patterns. Subsurface flow wetlands provide a low-cost, very low-energy, natural treatment system.

Subsurface wetlands are a proven way to remove organic matter and suspended solids from greywater and blackwater. They have been used in many parts of the world, especially in Europe, to treat greywater in high density developments. Subsurface wetlands are used in Australia to treat greywater. Colleges and buildings at Charles Sturt University use wetlands successfully. A subsurface wetland is proposed to treat laundry water from the Department of Human Services housing, to irrigate Fitzroy Gardens. Wetlands provide a good quality effluent with typical average effluent BOD and TSS less than 20 mg/l.

The treatment environment within a subsurface wetland is mostly anoxic or anaerobic. While some oxygen is supplied to the roots it is likely to be used up in the process of biomass growth and, for this reason, subsurface wetlands are effective in denitrification.

During design, attention needs to be given to in-flow distribution, and the placement of larger aggregate within the inlet zone. It is especially important, in subsurface wetlands, to ensure that blockage of the inlet zones is avoided. Blockages can cause short circuiting and surface flow. Inlet apertures need to be large enough to avoid algal growth blockages.

Primary design criteria for subsurface flow wetlands are:
* detention time;
* organic loading rate;
* hydraulic loading rate;
* media size;
* bed depth; and
* aspect ratio.

Typical Sizing

Wetlands should be sized at one to two metres square of surface area per person. The design is dependent on water quality, specifically BOD concentration, plant selection and environmental conditions such as natural light. Depths of subsurface flow wetlands are typically half a metre but no more than 0.6 metres. The Terraces case study in Part Two illustrates how subsurface wetlands can be designed for a small inner-city house.

Maintenance

Subsurface flow wetlands require routine operation and maintenance. Maintenance procedures include routine monitoring of the distribution and collection systems, and removal of settled sludge from the pre-treatment tank. Dead plant material does not need to be removed from the wetland, but routine weeding of the wetland system is required.

Cost

A wetland designed to treat greywater for 500 people will generally cost from $100,000 to $150,000, although costs will vary depending on site constraints and treatment load.

References

The CERES biofilter employs a reed bed to treat its wastewater. Subsurface wetlands typically form a component of the landscape on the site and thus form an integral part of the aesthetics of a residential development. CERES biofilter - www.ceres.org.au

Typical overseas design criteria are provided in Crites and Tchobanoglous (1998) Small & Decentralized Wastewater Management Systems, McGraw-Hill.

The general guidance on subsurface flow wetlands has been broadly sourced from DNRM (2000).

Fact Sheet 4b:

Surface wetlands

Typical application scale: regional and precinct

Constructed surface wetland systems, such as the Royal Park and Docklands Park wetlands, use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. They generally consist of:
* an inlet zone, (a sediment basin for the removal of coarse sediment);
* a macrophyte zone (a shallow, heavily-vegetated area for the removal of fine particulates and uptake of soluble pollutants); and
* a high-flow bypass channel (to protect the macrophyte zone in times of heavy rainfall).

Fact Sheet 3c has more information on sedimentation.

Wetland processes are improved by slowly passing run-off through heavily vegetated areas, allowing plants to filter sediments and pollutants from the water. Biofilms that grow on plants absorb nutrients and other associated contaminants.

While wetlands can play an important role in stormwater treatment, they can also have significant community benefits. Wetlands provide habitat for wildlife and a focus for recreation, such as walking paths and resting areas. They can also improve the urban environment and can be a central landscape feature. The City of Melbourne strongly supports engaging the community in wetland design.

Wetland systems provide flood protection when used in retarding basins. An open water body or pond at the downstream end of a wetland can provide water storage for reuses, such as irrigation.

Wetlands can be constructed on many scales, from small scales, house block sites to large precinct and regional systems. In highly urban areas they can have a 'hard edge form' and be part of a streetscape or building forecourts such as the Docklands development (Case Study Three). In regional settings they can cover more than 10 ha and provide significant habitat for wildlife.

Inlet zone

The wetland inlet zone (or sediment basin) regulates flow into the macrophyte zone and removes coarse sediments. The inlet zone allows the engagement of a bypass pathway once the macrophyte zone has reached its operating capacity.

The inlet zone reduces flow velocities and encourages settling of sediments from the water column. Inlet zones can drain during dry periods and then fill during run-off events. They are sized according to predicted storm discharges and target particle sizes for trapping.

Sediment basin maintenance is usually required every two to five years. Sediment basins should be designed to retain coarse sediments only. The recommended particle size is 0.125mm. Highest contaminant concentrations are associated with fine sediments and therefore waste disposal costs for fine sediments can be much higher.

Macrophyte zone

It is important that the macrophyte zone can achieve well-distributed flows, able to pass through various bands of vegetation. Strong vegetation growth is needed for the filtration process, and to withstand flows through the system. Vegetation selection will depend on the regional climate. Flow and water level variations and maximum velocities are also important considerations. These can be controlled with an appropriate outlet structure.

Different zones in a macrophyte system perform different functions. Ephemeral areas are often used as organic matter traps. These areas become wet and dry regularly and thus enhance the breakdown process of organic vegetation. Marsh areas promote epiphyte (biofilms) growth and filtration of run-off. Epiphytes use the plants as substrate and can effectively promote adhesion of fine colloidal particulates to wetland vegetation and uptake of nutrients. Generally, there are areas of open water surrounding the outlet of wetlands. These can increase UV disinfection and provide habitat for fish and other aquatic species.

Optimal detention times in the wetland (typically designed for 72 hours) ensure desired performance. The macrophyte zone outlet must therefore be sized accordingly. Multiple level orifice riser outlets are considered to give the most uniform detention times for wetlands. Sizing curves for wetlands are presented in Figure Ten, with total nitrogen (TN) the limiting design parameter. For a desired performance (typically 45 per cent TN reduction), the required wetland surface area is calculated as a percentage of the impervious catchment area to be treated, given a Melbourne location using average rainfall rates.

Fact Sheet 4c:

Ponds and Lakes

Typical Application Scale: Precinct and Regional

In the context of WSUD, ponds and lakes are artificial bodies of open water usually formed by a simple dam wall with a weir outlet structure. Ponds in the City of Melbourne not only provide an aesthetic quality but are also functional. Ponds and lakes typically have a water depth that is greater than 1.5 m. There is usually a small water level fluctuation, although more recently designed systems may have riser style outlets. This allows for extended detention and longer temporary storage.

Ponds promote particle sedimentation, adsorption of nutrients by phytoplankton and UV disinfection. They can be used as storages for reuse schemes and urban landform features for recreation as well as wildlife habitat. Often wetlands will flow into ponds and the water body enhances the local landscape.

Ponds can be used for water quality treatment, typically in areas where wetlands are unfeasible such as where there is very steep terrain. In these cases, ponds should be designed to settle fine particles and promote submerged macrophyte growth. Aquatic vegetation also plays an important function in water quality management. Fringing vegetation, is necessary to reduce bank erosion and is aesthetically pleasing, however it does not contribute greatly to improving water quality.

Ponds provide a valuable storage of water that can potentially be reused, such as for irrigation. Ponds or lakes can be focal points in residential developments, with houses and streets having aspect over open water.

Ponds are seldom used as 'stand-alone' stormwater treatment measures. As a minimum, ornamental ponds require pre-treatment with sediment basins. The sediment basins require regular maintenance (refer to fact sheet 3c for more details). In many cases, these ponds ultimately become the ornamental water body that require water quality protection.

There have been cases where water quality problems in ornamental ponds and lakes are caused by poor inflow water quality, especially high organic load, infrequent water body 'turnover' and inadequate mixing. Detailed modelling may be necessary to track the fate of nutrients and consequential algal growth in the water body during periods of low inflow (and thus long detention period). As a general rule, it is recommended that the mean turnover period for lakes during the summer periods should be in the order of 30 to 40 days (i.e. the lake volume should not be greater than the volume of catchment run-off typically generated over a 30 to 40 day period in the summer months). In the absence of these hydrologic conditions, it may be necessary to introduce a lake management plan to reduce the risk of algal blooms during the dry season. In spite of this, there may be an objective to maximise the size of the pond as a water feature for residential development.

Fact Sheet 5a:

Biological treatment processes - suspended growth systems

Typical application scale: site and precinct

Biological treatment processes are complex, engineered systems designed to accelerate natural biological processes to remove soluble (and some insoluble) pollutants from water. Suspended growth systems use micro-organisms freely suspended in water to oxidise organic and ammonium nitrogen (to nitrate nitrogen); decrease suspended solids concentrations; and reduce pathogen concentrations. Read on for examples of biological treatment processes.

Activated sludge process

Activated sludge is a suspension of micro-organisms in water. The micro-organisms are activated by air used to provide oxygen. The activated sludge process is an aerobic suspended-growth process.

Processing and disposal of a relatively large quantity of sludge must be considered in the design and operation, in addition to energy requirements for aeration.

This treatment is ideal for blackwater treatment, due to its high organic concentration. A minimum nutrient level is also required for optimal performance. Hence these systems are more suited to blackwater rather than greywater treatment.

Sequencing batch reactor (SBR)

A sequencing batch reactor (SBR) is an activated sludge process where all the main treatment steps occur in the same reactor (as illustrated in Figure 11). The sequence that occurs within a batch reactor usually runs like this:

* fill with influent;
* react (usually with aeration);
* settle;
* draw and decant; and
* idle.

A variation on this true batch reactor is a continuous flow reactor that fills and withdraws during the cycle.

Treatment variations

Pure oxygen activated sludge processes aerate with conventional activated sludge processes with pure oxygen and usually require supplementary mixing due to the decreased gas flow rate.

Activated sludge processes add activated carbon to enhance treatment, particularly by adsorption, and provide a surface for biofilm growth.

Advanced biological processes create conditions to suit specific microbial processes targeting enhanced nitrogen removal and phosphorus uptake.

Typical sizing

For a flow of 40-50 kl/d an area of 20m2 is typically required. As a typical rule of thumb the footprint for a suspended growth system is about 0.1m2/person.

Maintenance

All mechanical inputs will require regular maintenance. Periodic de-sludging of reactor vessels is also required. Operation costs include liquid pumping and energy to operate the aerator.

Typical Cost

$150,000 to $200,000 for a complete suspended growth system.

Membrane bioreactor

A membrane bioreactor (MBR) combines a biological reactor and membrane filtration into one process. The treatment process has a small footprint and generates high quality effluent with low TSS, BOD, and turbidity. These are relatively new processes. A demonstration plant has been installed at Werribee.

There are two basic configurations for a MBR: a submerged, integrated bioreactor that immerses the membrane within the activated sludge reactor and a bioreactor with an external membrane unit.

Membrane bioreactors are a proven, reliable treatment technology, used extensively in Japan for greywater and blackwater reuse systems. MBRs that combine filtration and biological treatment in one system provide a small footprint and replace the need for a separate filtration process. MBRs also provide high quality effluent and will meet almost all health criteria guidelines.

Membrane replacement is costly and so the life of the membrane is an important issue. In some cases, operating experiences has shown membranes need to be replaced every two years instead of an expected five years. Control of membrane fouling is an important operational issue. If fouling is not controlled, membranes will wear quicker, and there will be increased energy costs and a decrease in effluent quality. MBRs also have higher capital cost and energy costs than other treatment systems.

Typical Sizing

MBRs have a compact footprint with less than 0.1 m2 per person required.

Typical Cost

$400,000 for a 100kL/day plant with operating costs for maintenance and membrane replacement approximately $25,000 per year.

Suppliers

MBR suppliers include:
* Environmental Solutions International: www.environ.com.au/ (Supplier of Kubota MBRs)
* Aquatec-Maxcon: www.aquatecmaxcon.com.au/sewagetreatment/
* Vivendi's package treatment plant - The membrane bioreactor consists of an activated sludge process, followed by a microfiltration plant housed as a skid mounted package plant. An optional chemical dosing system for phosphorous removal can be included (www.vivendiwater.com.au).

Refer to www.membrane-bioreactor.com for more information.

Other treatments and references

This fact sheet presents a summary of the key biological treatments suited to the City of Melbourne. Other technologies, such as anaerobic digesters, designed for high organic loads may be suitable for some applications.
* Environmental Solutions International - www.environ.com.au/sbr.shtml
* Testech Engineering Group www.te-group.net/ - BIOJETTM SBR system
* Aeroflo activated sludge process 'IDEA' www.aeroflo.com.au/index.html - single reactor batch system.

Fact sheet 5c:

Biological treatment processes - fixed-growth systems

Typical application scale: site and precinct

Biological treatment systems are used to remove dissolved and colloidal organic matter from water.

Biological treatment promotes natural processes that break down high nutrient and organic loading in waters.

Fixed-growth refers to systems where the micro-organisms are attached to a surface that is exposed to the water.

Typical fixed film growth systems are:
* trickling filters;
* rotating biological contactors; and
* membrane bioreactors.

Trickle filter

A trickle filter is an aerobic fixed film biological reactor. In a trickle filter, water trickles over a bed of media. The fixed biological film grows on the media's surface. Oxygen is provided by natural or forced aeration through the media. Soluble organic matter is transported to the biological film through trickling water that flows over the growth attached to the media. The biofilm attached to the porous media metabolises the soluble and colloidal organic matter. This process reduces the organic content and treats the water.

A large surface area and high void volume promotes efficient treatment. This ensures good contact between the organics in the water and a high oxygen concentration for metabolic growth. Highly variable microflora populate the trickling filter, with bacteria the main microbial group. Synthetic media is used for efficient biofilm growth. Rock or plastic pieces are often used as a cheaper option.

After treatment, the biomass (the combination of the biological products) can be separated by settling or wetlands. Filtration is not a significant removal mechanism in this biological process. Variations of the process include one or two stage trickle filters with the incorporation of clarifiers (a sedimentation separation device with smaller space requirements).

Rotating biological contactor (RBC)

The rotating biological contactor (RBC) is a modified form of a trickling filter. Rotating discs support active biofilm growth. This biofilm metabolises, removing organic material from the wastewater.

RBCs are available in 'package treatment plants' for easy installation and operation. Package treatment plants contain a primary sedimentation tank, the biological chamber, a secondary clarifier and a sludge storage zone. They come packaged in containers with their own electrical device and remote telemetry systems.

The rotating shaft naturally aerates the biomass. Wastewater flows perpendicular to the discs and flows under gravity and displacement. The RBC has a number of baffled chambers to ensure a well-mixed reactor. Rotation also causes biomass 'sloughing' (excess biomass sliding) from the discs. Biomass clarification is used to remove this excess.

For the City of Melbourne applications, the RBC typically has a small footprint making them suitable for medium to high density applications. Water quality and quantity determine media sizing and hence unit size.

Typical Sizing

Fixed growth biological systems have a small compact footprint. They require a footprint of approximately 30 to 40m square, to treat a flow of 20 kl/d with a minimum height of two metres. The basement is a suitable spot for an RBC, and provided there is adequate ventilation.

Maintenance

Monthly maintenance of two to three hours are required each month, with an annual maintenance check of six to eight hours. Fixed growth systems are usually self-cleaning, and alarms can be connected to telemetry systems.

Typical cost

$150,000 to $200,000 for a complete fixed growth system.

Suppliers

There are a number of suppliers of RBC and trickling filter package treatment plants in Australia. Further information about systems can be obtained from the following suppliers:
* EPCO Australia www.epco.com.au/
* Water Recycled Group: www.waterrecycle.com.au (modified RBC package plant)

* Diston Sewage Purification www.distonsewage.com.au/RBC.htm
* The Novasys Group: www.novasys.com.au/ (supplier for Gmbh - a supplier of RBCs used in Germany for greywater
* reuse)
* Aquapoint's Bioclere: www.aquapoint.com
* Enviroflow: www.enviroflow.com.au

Fact sheet 5c:

Biological treatment processes: recirculating media filters

Typical application scale: site and precinct

Recirculating textile or sand filters

Recirculating textile filters (RTF) and recirculating sand filters (RSF) are both biological treatment processes for removing organic material from wastewater, with one using textile filtering and the other using sand. Recirculating textile filters are similar to trickling filters, but instead of using plastic or rocks as the media for the growth of biofilms, textiles are used. RTFs are available in small compact footprint package plants, suitable for decentralised treatment.

RTF and RSF consist of two major components:
1. A biological chamber and low pressure distribution system. Wastewater flows between and through the non-woven light-weight textile material in the RTF and through a bed of sand in the RSF.
2. A recirculating tank and pump. 80 per cent of the filtrate is pumped back to the chamber. The pump fills the chamber every 20 to 30 minutes. The remaining effluent can be diverted to a storage tank or disposed of.

The recirculating filters are usually packaged systems which integrate the media, the container, the distribution system, recirculating tanks and pumps and also a telemetry system for external monitoring. Recirculating filters (RFs) are a reliable, low-maintenance treatment system for decentralised wastewater systems. Recirculating filters also provide a high quality effluent of less than 10mg/l BOD and TSS. RFs have been proven for single-lot dwellings, with good results. Their use in the treatment of greywater in high density applications is not well studied.

Recirculating sand filters have been used for treatment of greywater with good results in single dwelling houses. The Healthy Home in Queensland is one example where effluent quality of treated greywater has been high, with less than 10 mg/l BOD and TSS and for faecal Coliforms less than 10cfu/100ml.

A variation on the design is the single pass sand/textile filters. With this design, no recirculation tank or pump is required. A larger filter is required for equivalent performance.

Maintenance

Recirculating filters require routine maintenance systems. Maintenance requirements are simple. Monitoring the distribution system to the filter, maintaining and replacing the filter surface as necessary and flushing the distribution system manually are all that is usually required.

Typical sizing

RTFs are available in small compact footprint package plants. To treat a flow of 20 kL/d, an RTF requires 15 to 20m2 with a hydraulic loading of 100 to 180 m3/d. This compares to a RSF system which may require a 100m2 footprint with a hydraulic loading of 20 to 30 m3/day.

Typical cost

These systems typically cost $100,000 to $200,000 for a complete recirculating filter system.

Suppliers

Innoflow technologies www.innoflow.co.nz/ (Australian and NZ Supplier of Orenco Systems)

Fact sheet 5d:

Separation: sand and depth filtration

Typical application scale: site and precinct

Introduction

Filtration is a tertiary treatment process that occurs after a secondary biological process. Filtration may be required to remove residual suspended solids and organic matter, to ensure more effective disinfection. There are two major types of filters: sand and depth filtration (Fact Sheet 5d) and membrane filtration (Fact Sheet 5e).

Filters have been used for water treatment for over 100 years. Sand (or other media) filters treat settled wastewater effluent. For on-site treatment, sand filters are usually lined, excavated structures filled with uniform media over an underdrain system. The wastewater is dosed on top of the media and percolates through to the underdrain system. Design variations include recirculating sand filters where the water is collected and recirculated through the filter (Fact Sheet 5b).

Sand filters are essentially aerobic, fixed film bioreactors. Straining and sedimentation also occur, removing solids. Chemical adsorption to media surfaces removes dissolved pollutants such as phosphorous.

Sand filtration

With sand filtration, water is applied to the top of the filter and allowed to percolate through the media. With time, the head loss builds up and the filter media has to be cleaned by backwashing. Most removal is done by straining, where particles larger than the pore space are strained out, and smaller particles are trapped within the filter.

Hydraulic flow rate will determine the dominant pollutant removal mechanisms. Pollutants are physically removed by infiltration. Larger particles are retained within the filter media by filtration. If organic, they will decompose during low dose periods.

Typically, a biofilm forms on upper layers. This layer assists in the absorption of colloidal pollutants, and encourages oxidation of the organic material. A low flow through the sand filter is desirable to ensures contact between the sand media's biofilm and water. A low flow means effective microbial control. During low flow, the interstitial spaces between the sand granules enable oxygen to diffuse to the biofilm, encouraging oxidation of organic material.

Different designs for sand filters are based on the type of media, whether the operation needs to be taken off line to be backwashed, and whether the flow is up or down through the sand filter.

Design considerations

* type and size of filter media;
* filter bed depth;
* hydraulic loading rate;
* organic loading rate; and
* dosing frequency and duration.

Maintenance

Maintenance is required to ensure:
* there is no build up of oil and grease on the filter media;
* the prevention of the agglomeration of biological flocs, dirt and filter media into mudballs, preventing effective back-washing; and
* loss of filter media is controlled.

Typical Cost

A simple sand filter product with a small footprint can be provided as a package system. Aquatec Maxcon offer a small footprint pressure sand filter for approximately $20,000. These systems have an automatic backwash system, controlled by head loss or effluent quality. Cheaper pool filters ($1,000) used for filtering swimming pool and spa water may also be adapted for tertiary filtration.

Depth filtration

Depth filtration is a variation of a sand filter. Depth filtration uses a granular media, typically sand or a diatomaceous earth, to filter effluent. Typically there are four layers of filter media. The particle size decreases through the filter layers. The coarse, top layer removes larger particles, with finer material removed in the lower layers. This comprehensive filtration system offers improved filter efficiency when compared to a conventional sand filter.

Maintenance and design considerations are similar to sand filtration.

Fact sheet 5e:

Separation: membrane filtration

Typical application scale: site and precinct

Membrane filtration, or cross-flow membrane filtration, is a physical separation process that filters pollutants using a semipermeable media. There are four classes of filtration:
* micro-filtration (MF) with the largest pore size;
* ultra-filtration (UF) with smaller pore size;
* nano-filtration (NF), smaller again; and
* reverse osmosis (RO), the smallest.

As water passes through a membrane under pressure, it 'squeezes' through the structure. The membrane selectively traps larger pollutants. The feed-stream is effectively split into two effluents: a purified stream and a waste stream.

Membrane filtration processes can remove particles, bacteria, other micro-organisms, particulate matter, natural organic matter (NOM) and salt (desalination). Removal is determined by the membrane's pore size (see below). As the pore size decreases, smaller pollutants can be removed. The smaller the pore sizes, the more pressure and energy consumption required. Refer to the table below for more details.

Continued innovation, and the modular design of membrane filtration processes for small scale applications, means that the operational and economic feasibility of these systems is improving. Membrane filtration systems are now available in modular treatment plants, well suited for sewer (water) mining, greywater treatment and groundwater treatment.

Design issues

Water quality and available space will determine membrane configuration. Pre-treatment may be required to remove larger particles, and natural organic impurities, to improve effectiveness. UV disinfection after filtration is recommended for microbial control.

Selection issues

Desired water quality, and water end use, pollutant size and type present are all factors to consider.

Pollutant build-up on the membrane surface means that membrane fouling is expected. A quick backwash system, integrated into the plant's operation, will manage fouling. Periodic chemical cleaning is required to rejuvenate the membranes. Membranes have a finite life and are typically replaced every two to five years.

Higher operating pressure increases permeate flow thereby increasing efficiency, but it increases the fouling rate. Higher flow velocity across the membrane reduces the fouling. An optimal operating condition exists between flow and pressure.

Adequate provision for the disposal of the waste stream is also necessary. Membrane processes produce a waste stream of about 15 per cent of total feed volume, up to 50 per cent in some reverse osmosis operations. Waste disposal must be considered during design. For sewer mining, the waste stream is typically directed back into the sewer.

Table 2.

Membrane filtration key features summary

Filtration	**Pore size**	**Operating pressure**	**Typical target pollutant**
Micro filtration	0.03 to 10 microns	100-400 kPa	Sand, silt, clays, Giardia lambia, Cryptosporidium.
Ultra filtration	0.002 to 0.1 microns	200-700 kPa	As above plus some viruses (not an absolute microns barrier). Some humic substances.
Nano filtration	Approximately 0.001 microns	6.00-1,000 kPa	Virtually all cysts, bacteria, viruses

			and humic materials.
Reverse Osmosis	Approximately 4 to 8 A	300 - 6.000 (or 13,000 kPa - 13.8 bar) kPa	Nearly all inorganic contaminants Radium, natural organic substances, pesticides, cysts, kPa bacteria and viruses. Salts (desalination).

Reverse osmosis

Reverse osmosis (RO) is the finest membrane filtration process, with the smallest pore size. At around four to eight angstroms (about the size of a molecule), reverse osmosis also has the highest pressure requirements. RO removes most pollutants including pathogens, viruses and salts, and is used for sewer mining and desalination. RO can separate ions (dissolved salt) from water, producing high quality water. A very high pressure (determined by the osmotic pressure and ionic concentration) is required, which uses a lot of energy. Regular maintenance is required because the small pore size is easily blocked or fouled. Fouling can be managed by an upstream water treatment like sedimentation. Reverse osmosis units are really effective when used in a series configuration.

RO membranes are generally made from cellulose acetate and polyamide polymers. Chlorine concentration can damage RO membranes. The cellulose acetate can tolerate chlorine levels used for microbial control, but chlorine will destroy polyamide polymers.

Typical costs

Membrane filtration plants range according to pore size and operating pressure. Membrane filtration plants start from approximately $60,000 for a 50kL/day with a typical cost for a combined microfiltration and reverse osmosis plant to treat 100kL/day is $750,000.

Suppliers

* Waste Technologies of Australia: www.wastetechnologies.com/MWR.htm

* Veolia Australia - www.vivendiwater.com.au
* GE water - Osmonics - www.gewater.com/
* US Filter - Memcor - www.water.usfilter.com/

Fact sheet 5f:

Disinfection

Typical application scale: site, precinct and regional

Disinfection minimises pathogenic microorganisms, protecting public health. Disinfection destroys pathogenic microorganisms in water. Eradication of water-borne pathogens is the most important public health concern for water treatment.

Disinfection ranges from boiling water to large scale chemical treatment for water supplies. The three most common disinfection methods are UV radiation, chlorination and ozonation.

UV disinfection

Ultraviolet (UV) disinfection uses UV light to inactivate micro-organisms in water. The short UV wavelength irradiates the micro-organisms. When the UV radiation penetrates the cell of an organism, it destroys the cell's genetic material, and its ability to reproduce. UV disinfection has low capital and operating cost, it is easy to install and operate and is well-suited to small-scale water treatment processes.

UV provides a reliable low-maintenance disinfection system without the need to handle or store hazardous materials. No chemicals are required, eliminating the need for hazardous chemical handling and storage. No harmful by-products are formed and odour is minimised. UV disinfection is a physical process independent of pH, with temperature having minimal impact.

UV disinfection effectiveness depends on the water quality and characteristics. The effectiveness of UV disinfection is influenced by:
* the intensity of UV radiation;
* amount of time exposed;
* reactor configuration; and
* the concentration of colloidal and particulate constituents.

UV radiation intensity depends on its source, that is, the distance between the lamp and water. Reactor designs should ensure uniform flow with maximal radial motion to ensure a well-mixed water flow receives ample exposure to the UV radiation. In a natural system, UV radiation supplied by the sun provides limited disinfection.

Usually UV disinfection systems are installed towards the end of the treatment train to minimise fouling and interference with colloidal and particulate constituents. Suspended solids reduce UV effectiveness by reducing transmission and shielding bacteria. Cleaning is essential to ensure effective UV transmission. Maintenance is required to manage UV tube fouling.

Chlorination

Chlorine is the most common water disinfectant. Chlorine, a strong oxidant, can either be added in the gaseous form (Cl_2), hypochlorous acid or as hypochlorous salt (typically $Ca(OCl)_2$). Chlorine use means chemical handling and storage is required.

Chlorine provides residual microbial control, that is, it continues to disinfect water after it has passed through the treatment process. It is typically selected for potable water supply systems. Optimal chlorination dosage is dependent on the concentration and water pH and temperature. The pH exerts a strong influence on the chlorination performance and should be regulated.

Chloramination is the mix of chlorine dosing with ammonia for disinfection. It is designed to reduce by-product formation and reduce trihalomethanes (THM) concentrations. Chloramines last longer in water, providing a degree of residual protection.

The residual unpleasant taste and odour of chlorine is a disadvantage of this method of disinfection. By-products of chlorination could be carcinogenic, with particular concern over trihalomethanes.

Ozonation

Ozone is a more powerful oxidising agent than other previously discussed disinfectants. Ozone is created by an electrical discharge in a gas containing oxygen ie. $3O_2$ becomes $2O_3$. Ozone production depends on oxygen concentration and impurities such as dust and water vapour in the gas.

The breakdown of ozone to oxygen is rapid. It is impossible to maintain free ozone residuals in water for any significant time.

Reference

US EPA (1999) Ultraviolet disinfection, report EPA 832-F-99-06.

1. Information sheet

Saving Water Around The House

What can I do to use less water?

There are simple things that you can do around the house to conserve water. Recognising the value of water is the first step. Conserving water now means more water will be available and affordable in the future. You can help conserve water by changing some of your every day habits, like:
* turning water off while cleaning your teeth;
* shaving with the plug in the sink;
* taking shorter showers;
* living with a small garden;
* sweeping with a broom rather than using the hose. Paved areas must be cleaned without water under permanent water measures.

Where do I use water in my household?

To find out where most water is used in your home, complete the water audit form developed by the City of Melbourne. You'll find this form at www.melbourne.vic.gov.au/info.cfm?top=120&pg=11

Do I need water-efficient appliances and fittings?

To save even more water, water-efficient fittings and appliances are an excellent idea, and they're suitable for most homes and small businesses and for most appliances. Options include:
* water-efficient fittings including showerheads, waterless urinals and taps;
* water-efficient appliances including AAAAA-rated washing machines and AAAA-rated dishwashers; and
* pressure reduction valves that reduce water pressure, saving more water.

These measures will save up to 15 per cent of water use compared to a typical household.

Water efficiency ratings should be shown on all new washing machines and dishwashers. The ratings are co-ordinated by the Water Services of Australia Association and are available from their website at: www.wsaa.asn.au

The Department of Sustainability and Environment runs the Our Water, Our Future program, and produces a water saving kit. Order yours online at: www.ourwater.vic.gov.au or call 136 186.

How can I save water in my garden?

Garden watering accounts for 35 per cent of total water usage. You can reduce the amount of water your plants need by:

* watering at night time (now mandatory for watering systems);
* watering with a hand held trigger hose (now mandatory);
* using mulch in the garden;
* designing a low-water garden by;
  - using native plants or plants that require little water (known as xeriscape plants);
  - hydrozoning plants. This means putting plants with similar water requirements together, so you can target spots to water; and
* moisture-controlled irrigation systems.

Contact your local nursery or Sustainable Gardening Australia www.sgaonline.org.au for more information.

What about washing my car?

Using a bucket and sponge to wash your car is the best option. Permanent water measures require that hoses have trigger nozzels on them for washing the car.

What about my pool?

Pools can lose water through evaporation. Covering your pool between uses can help reduce water loss through evaporation, reducing the need to 'top-up' your pool.

Can I install a rainwater tank?

Yes - rainwater tanks are a great way to preserve our existing resources. Rainwater is best used for toilet flushing, replacing the high-quality drinking water usually used in the toilet. Rainwater harvested from your roof is stored in a tank. Using collected rainwater for toilet flushing means using 20 per cent less drinking water. The fall of your roof and the position of downpipes can determine how effective your rainwater tank will be. To collect as much rainwater as you can, all (or as many possible) downpipes should be directed to the tank.

What size and shape tank should I install?

To size a rainwater tank for your house, **refer to the City of Melbourne's Fact Sheet Rainwater Tanks - General, and Fact Sheet Rainwater Tanks for the Household for guidance**. To find the right size tank you need to know:
* the size of roof area collecting rainwater; and
* the intended water use e.g. toilet flushing.

Tanks suitable for inner-city houses range from 1.5 kL to 4 kL. There is little value installing a tank if the ratio of people to roof area is less than 15m2 per person.

Rainwater tanks are usually cylindrical, but there are other options, including:
* incorporation of tanks into gutters: www.rainsaver.com.au
* polypropylene sacs for water storage: www.rainreviva.com.au
* boundary fence tank storages: www.freewater.com.au

Tanks can also be installed underground.

How do I maintain my rainwater tank?

Rainwater tanks require minimal maintenance. The quality of water is directly related to the condition of the roof. The roof should be clean and rust free. All gutters should be clear and clean. Gutter guards are recommended, to prevent leaves and other debris entering the tank. The tank should be closed, with mosquito nets preventing insects entering the tank. Every six months, the tank should be inspected to maintain these standards.

Detailed maintenance requirements are available from the Federal Government's enHealth publication, Guidance on the use of rainwater tanks.
www.enhealth.nphp.gov.au

Are there any rebates for my tank?

The Department of Sustainability and Environment. through the Our Water, Our Future program is offering a rebate for rainwater tanks and installation. The rebate is $300 ($150 for a tank and $150 for toilet connection). Visit www.ourwater.vic.gov.au or call 136 186 for more information.

How do I install my rainwater tank?

Installations must conform to Australian standards (AS3500.1.2 Water Supply: Acceptable Solutions) and should be completed by a licensed plumber. The Green Plumbers www.greenplumbers.com.au and the Plumbing Industry Commission www.pic.vic.gov.au have more information.

Do I need approval for my rainwater tank?

The City of Melbourne requires a planning permit for the installation of tanks within Heritage Overlay areas and for tanks larger than 4,500 litres. Tanks outside Heritage Overlay areas and smaller than 4,500 litres, have Victorian Government exemption (Clause 62.02 of the Victorian Planning Provisions). The City of Melbourne can advise on exemptions.

Due to the heritage nature of the City of Melbourne, most properties must lodge a planning permit for their rainwater tank. For works less than $10,000 on a single dwelling on a lot, there is no fee for a planning permit. The planning permit only needs to address issues relating to heritage, primarily, whether the tank can be seen from streets and or laneways, and its effect on existing fabric.

Buildings listed on the Victorian Heritage Register need a Heritage Victoria permit under the Heritage Act 1995. Once approved, a planning permit is not required.

For rainwater tanks installed within the building fabric, such as in a roof space, or in the upper floors of an apartment building, a building permit may be required. The building must be able to support the tank weight. Contact the City of Melbourne for more advice.

Where can I find more information?

For further information refer to City of Melbourne's WSUD Guidelines, including the Rainwater for household tanks Fact Sheet and the Terraces case study in Section Two.

2. Information sheet

Reusing Water Around The House

What else can I do to save water?

Reusing water within your household will help save more water. The most common way to reuse household water is with a greywater reuse system.

What is greywater?

Greywater is water that has been used in the laundry and the bath or shower. This water can generally be reused. Greywater reuse can save significant quantities of tap water. Reusing your greywater also reduces the amount of water that enters sewers, saving energy and resources.

Greywater contains contaminants and is not fit for human consumption. Low levels of bacteria, faecal matter, organic matter, micro-organisms, salts and detergents are common, and all can contribute to the colour and odour of the water. It is important to limit human exposure to greywater.

Where should I collect my greywater?

'Light' greywater is wastewater from the shower, bath and basin in bathrooms, and requires the least amount of treatment prior to reuse. These are the preferable sources for greywater collection.

What can I use greywater for?

Greywater can be used for garden irrigation, or, after treatment, for toilet flushing. No treatment is required if the greywater is diverted immediately to a subsurface irrigation. Greywater should not be used to irrigate vegetable gardens, and should not be used during wet weather.

How can I reuse water?

Collecting greywater for reuse could be as simple as putting a bucket in the shower to collect water for your pot-plants, or more complicated, involving treatment before reuse in toilet flushing.

Simply diverting greywater to the garden for irrigation is an easy option. Greywater can be used immediately, so it needs little treatment. A diverter could redirect greywater from your washing machine, screening water before diverting it to an underground (subsurface) garden irrigation. This system minimises human contact. A diverter could be retrofitted to your existing building (usually near the laundry), after appropriate plumbing. Water is fed through the diverter to an underground (subsurface) irrigation system. It's the green way to 'multi-task' - you can be watering the garden while you do your laundry!

No approvals are necessary for simple diversion devices. All plumbing should be completed by a licensed plumber.

Are there any health risks?

Correct management and appropriate water use will ensure your greywater is safe. Ideally, collection, treatment and reuse should be done through a closed system, minimising health risks. Simple precautions that can help protect health include:

* avoid cross connections between greywater and drinking water systems;
* ensure excess greywater is directed to the sewer;
* contain greywater reuse within your residential boundaries;
* ensure people cannot touch or otherwise be exposed to greywater;
* never use greywater on your vegetable/herb garden;
* don't allow greywater to 'pond', especially in wet weather; and
* have an overflow connection to the sewer.

Can I store greywater?

Greywater can be temporarily stored and reused on site. The Department of Human Services does not recommend the use of untreated greywater within the household *1, but it is fine to use in garden irrigation. Greywater can be stored for up to 24 hours without treatment before it must be discarded to sewer. Storing untreated greywater is hazardous, as it can harbour microbial growth, producing odours and septic water.

If greywater is to be stored for greater than 24 hours, treatment is essential.

What type of greywater treatment system can I use?

There are many greywater reuse options. The method you select will depend on the water quality you need and how much space you have. The City of Melbourne has fact sheets available, to help you choose the right method for your home.

Here's how a standard system would work

The mesh screen traps larger objects, like cotton or hair. The sedimentation tank regulates flow through the system, and allows some pollutants to settle to the bottom of the tank. Dissolved organic matter is reduced by the treatment technology (e.g. wetland). The small clarifier tank stabilises flow and removes excess living matter (biomass) by sedimentation. The UV disinfection kills micro-organisms including pathogens and bacteria. Finally the storage tank provides a reservoir to meet residential demand that varies over a typical day to supply.

The Environment Protection Agency Victoria (EPA) has a list of approved greywater types at their website: www.epa.vic.gov.au.

What are the maintenance requirements for my greywater scheme?

Each greywater treatment system has specific maintenance requirements. Manufacturers and suppliers can help with advice about particular systems. For example, with a subsurface wetland system, all that is required is regular cleaning and removal of solids from the screens.

Greywater plumbing should be connected to the mains sewer so that stored greywater can be disposed of when the system needs maintenance.

Do I have to use different detergents or shampoos?

If you use greywater for your garden, or a vegetated greywater treatment system like a subsurface wetland, you will need to carefully select your household cleaning agents, soaps and shampoos. Suppliers and retailers of greywater systems will advise on what products you should avoid for your specific system.

Are there any rebates for my greywater system?

The Department of Sustainability and Environment's Our Water, Our Future program offers rebates for greywater tanks and installation. Installing a greywater system can attract a $500 rebate. Visit www.ourwater.vic.gov.au or call 136 186 for more information.

How much does it cost?

Simple diversion devices cost around $360. Automated, and more complex greywater treatment systems, can cost from $5,000 to $10,000.

Do I need approval for my greywater system?

Simple greywater diversion systems do not require approval.

For systems treating less than 5,000 litres a day, EPA Victoria has provided a list of approved greywater treatment systems. The City of Melbourne can issue permits for EPA approved systems. Approved greywater devices are listed on the EPA Victoria's website www.epa.vic.gov.au, and EPA Publication 812 Reuse Options for Household Wastewater has more advice. EPA approval is not required for a closed system, when no water is released into the environment.

All installations must conform to Australian Standards, with reference to AS3500.1.2 Water Supply: Acceptable Solutions, wastewater treatment (AS1546), wastewater effluent management (AS1547), and plumbing requirements. A licensed plumber must install the system. Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for additional information.

The Department of Human Services has guidelines available at: www.health.vic.gov.au/environment

What do I do with my rainwater now that I have a greywater system?

Rainwater can be used for hot water. Hot water systems heat water to 60 to 70 degrees C. At this temperature, any pathogens are destroyed, and water is safe for use in your home including showering and cooking. For further information refer to City of Melbourne's WSUD Guidelines, particularly the Terraces case study in Section Two.

Where can I find more information?

More information is available in the City of Melbourne's *Total Watermark* policy and WSUD Guidelines.

3. Information sheet

- saving water in the office

How can I save water in my office?

There are simple things that you can do at work to conserve water. Recognising the value of water is the first step. Conserving water now means more water will be available and affordable in the future. You can help conserve water by making some simple changes:
* educating staff about water conservation;
* checking for leaking taps and fittings;
* installing lever or mixer taps so staff can find the right water temperature quickly, reducing waste water;
* sweeping with a broom rather than hosing. This is mandatory under water restrictions; and
* encouraging new ideas from staff.

Can I install water efficient appliances and fittings?

Installing water-efficient fittings and appliances saves water. Options include:
* water efficient fittings including taps, waterless urinals and dual flush toilets;
* water efficient appliances like AAAAA-rated washing machines and AAAA-rated dishwashers; and

* installing pressure reduction valves to reduce tap water pressure.

Water efficiency ratings should appear on all new washing machines and dishwashers. The ratings are coordinated by the Water Services of Australia Association. Go to: www.wsaa.asn.au for more information.

Water saving kits are available through the Department of Sustainability and Environment's program, Our Water, Our Future program. Rebates on water-saving initiatives are also available to non-profit organisations. Find out more at: www.ourwater.vic.gov.au or by calling 136 186.

How can my business encourage responsible water use?

Small and large businesses can incorporate water use into their sustainability strategies. As a part of your broader ecological sustainable development strategies, business practices and strategies can be developed to encourage a responsible and equitable approach to water use. Consider:
* buying supplies from water-conscious suppliers;
* include a water section in your triple bottom line reporting;
* include water conservation targets in your annual report;
* market the responsible nature of your business; and
* nominate a staff 'champion' of water sensitive urban design.

How is water used in my office?

Office buildings use lots of water for toilet flushing. Most offices have few showers and generate only a small amount of greywater.

Are there alternate water sources for toilet flushing?

Alternative water sources used in the City of Melbourne include harvesting rainwater from the roof and recycled water.

Is it worthwhile harvesting rainwater?

Buildings with large catchment areas (a large roof area) can harvest rainwater for toilet flushing and irrigation. If there is less than 15m2 of available roof catchment per person, rainwater harvesting is not usually worthwhile.

Rainwater harvesting has been incorporated into the Tivoli building, QVM, Carlton Gardens and Melbourne Museum, Ryder Oval and Docklands. More information about these sites is available in City of Melbourne's WSUD Guidelines.

Fact Sheet 2a Rainwater Tank - General has rainwater tank sizing and approval information.

What should I do with my stormwater?

All of our stormwater ends up in Port Philip Bay. To protect the health of the bay and our quality of life, pollutants should be removed from stormwater before it enters the ocean. The City of Melbourne's WSUD Guidelines are an excellent resource for finding options for stormwater treatment.

Typical urbanisation produces many contaminants that can be blown or washed into waterways, affecting the health of streams and waterways. Nitrogen, phosphorous and suspended solids are common stormwater pollutants. Best practice stormwater management provides for treatment of run-off to remove water borne contaminants.

Where else can I get an alternative water source?

Waste water, known as blackwater, can be extracted from the sewer, treated and reused. The City of Melbourne has an extensive sewer network, designed to transport water to large scale treatment plants. Rather than transport this water from the city, potential exists to use this water as a resource. 'Reclaimed water' could be used to irrigate open space, or for toilet flushing.

Sewer mining, involves smaller, decentralised systems positioned throughout the City of Melbourne. Small treatment plants can produce required water quality and quantity on demand, a definite advantage.

Is treatment necessary?

Treatment is essential. Blackwater has high pathogen levels and must be disinfected before use.

What is sewer mining?

Sewer mining removes water from sewage (blackwater). Solids are separated and immediately returned to the sewer for centralised treatment at a sewage treatment plant. The water is then further treated to an appropriate quality, usually to a level suitable for toilet flushing and garden irrigation.

Sewer mining has been successfully applied in Melbourne with examples for irrigation including Albert Park *2, Flemington Racecourse and the Domain. CH2, the City of Melbourne's new building presently under construction, incorporates a blackwater treatment system situated in the base of the building with the water used for toilet flushing. The 60L - Green Building in Carlton is currently commissioning a biological process to reuse blackwater on site for toilet flushing *3.

The City of Melbourne's WSUD Guidelines Tivoli case study in Section Two, and Fact Sheets 5a-5e have more information about sewer mining.

What type of maintenance does a sewer mining system require?

All sewer mining systems require regular maintenance. The technology used will determine the maintenance management schedule required. Membrane filtration processes, for example, require regular membrane cleaning.

Operation can be effected by variable wastewater quality. A peak caustic load in the sewer from an industrial customer could potentially harm your system. Regulatory approaches have minimised these occurrences. License agreements stipulate acceptable pollutant loading, and the tracking of 'rogue' customers has improved significantly.

What else should I consider?

Blackwater treatment can be energy-intensive. Broader ecological sustainable development objectives, particularly the City of Melbourne's Zero Net Emissions By 2020 strategy, should be considered when making decisions about technology. Zero emissions can be attained by selecting energy efficient technologies and by purchasing or even generating renewable energy to power projects.

What approvals are required for sewer mining?

Water treatment systems that treat more than 5,000 litres a day require EPA approval. EPA Victoria's Use of Reclaimed Water guidelines (publication 464.2) are a good source of information for large scale water treatment systems.

Water quality is expected to be similar to the EPA Victoria's guidelines for reclaimed water. Water should be treated to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS) for toilet flushing and unrestricted irrigation. Class B (100 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) and Class C (1000 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) quality water is appropriate for restricted access irrigation *4.

EPA Victoria classifies blackwater systems treating less than 5,000 litres a day as septic systems. EPA Victoria has guidelines for on site wastewater treatment (refer to the Code of Practice - septic tanks; publication 451). The City of Melbourne has the approval authority for septic systems and can issue a permit. Approved treatments are listed on the EPA Victoria's website:
www.epa.vic.gov.au

All installations must conform to Australian Standards, with reference to AS3500.1.2 Water Supply: Acceptable Solutions, wastewater treatment (AS1546) and wastewater effluent management (AS1547), and plumbing requirements. A licensed plumber must install the system. The Green Plumbers www.greenplumbers.com.au and the Plumbing Industry Commission www.pic.vic.gov.au have additional information.

The Department of Human Services has responsibility for approving large scale reclaimed water systems where there is potential for 'high exposure' from Class A water applications. High exposure could include the use of reclaimed water for toilet flushing in a residential building or irrigating an unrestricted area. The Department should be contacted directly for approval.
www.health.vic.gov.au/environment

What can I do to improve my office garden?

You can save water in the garden by:
* using mulch;
* designing garden for low water requirements, including;
  - using native plant species or plants that require little water (known as xeriscape plants);
  - hydrozoning plants. This means putting plants with similar water requirements together to create targeted watering zones; and
* moisture controlled irrigation systems.

Contact your local nursery or Sustainable Gardening Australia www.sgaonline.org.au for more information.

Where can I find more information?

Refer to the City of Melbourne's *Total Watermark* policy and the WSUD Guidelines for fact sheets and applications in realistic scenarios.
Information Sheets 9

4. Information sheet

- industrial applications

How water is used in industry depends on the type of industry and the site. Water uses can range from cooling water for industrial equipment to very high purity water for technology companies.

How can I save water?

There are simple things that you can do at work to conserve water. Recognising the value of water is the first step. Conserving water now means more water will be available and affordable in the future. You can help conserve water by making some simple changes:
* educating staff for water conservation;
* encouraging and rewarding new ideas from staff;
* checking for leaking taps and fittings;
* installing lever or mixer so staff can find the right water temperature quickly, reducing waste water; and
* changing work place behaviour. For example, sweeping with a broom rather than the hose.

Each user is different, and different water-reduction strategies are appropriate for different settings. The development or redevelopment scale, layout, proximity to wastewater treatment facilities and type of industry are all factors to be considered.

Where do I use water?

You can carry out a water audit of your business. The City of Melbourne's *Total Watermark* publication provides a water audit tool for households which can be adapted to industries. For large consumers, City West Water provides a free 'water audit' service. This helps to identify where water is used. Appropriate measures can then be taken to reduce consumption.

What types of fittings and appliance should I purchase?

Water can be conserved by the installation of water efficient fittings and appliances like:
* water efficient taps, showerheads, waterless urinals and dual flush toilets;
* water efficient appliances like AAAAA-rated washing machines and AAAA-rated dishwashers; and
* reducing pressure to taps by installing pressure reduction valves.

Water efficiency ratings should be shown on all new washing machines and dishwashers. The ratings are co-ordinated by the Water Services of Australia Association and are available at: www.wsaa.asn.au

What quality water should I use?

Industry should use 'fit-for-purpose' water and should demonstrate best water management and practice. Multiple uses of water within a manufacturing site, the use of reclaimed water for process cooling applications, and harvesting stormwater for on-site use are all good ways to conserve water.

Can I harvest rain water?

Industrial premises usually have large roof areas so rainwater collection could become a useful resource. Rainwater can be used in most industrial applications, but may require treatment. For a preliminary evaluation of tank size for your site, refer to Fact Sheet 6.

What about water recycling?

Water recycling is an alternative water source for industries. How you use water will determine the appropriate water quality and treatment level required.

On site water recycling is a good way to conserve water. Treatment may be necessary to improve water quality, but a range of technologies are available for treating recycled water. Package treatment plants with small footprints are available. Fact Sheets 5A to 5F have more information on recycled water.

What are the business incentives for improving our approach to water?

The price of water is expected to increase, reflecting the Victorian Government's pricing for sustainability approach, and tiered pricing structure. High water users are charged at higher rates. High water users will be targeted to reduce water consumption.

Presently, grants are available to assist innovative solutions for water consumption. Further information can be obtained from the Smart water fund established to promote water conservation and recycling initiatives. www.smartwater.com.au

How can my business encourage responsible water use?

You can incorporate water use into your sustainability strategy. As a part of your broader ecological sustainable development strategy, a responsible and equitable approach to water use can become a part of your business practices and strategies. Some ideas include:
* buying supplies from water conscious suppliers;
* include a water section in your triple bottom line reporting;
* include water conservation targets in your annual report;
* market the responsible nature of your business; and
* nominate a staff "champion" of water sensitive urban design.

What should I do with my stormwater?

All of our stormwater ends up in Port Philip Bay. To protect the health of the bay and our quality of life, pollutants should be removed from stormwater before it enters the ocean. The City of Melbourne's WSUD Guidelines are an excellent resource for finding options for stormwater treatment.

Typical urbanisation produces many contaminants that can be blown or washed into waterways, affecting the health of streams and waterways. Nitrogen, phosphorous and suspended solids are common stormwater pollutants. Best practice stormwater management provides for treatment of run-off to remove water-borne contaminants.

Where can I find more information?

Refer to the City of Melbourne's *Total Watermark* policy and the WSUD implementation for fact sheets and applications in realistic scenarios.

Do you have a question for the Melbourne City Council?
Call and speak to us.

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Footnotes

Section One

2 Victorian Government White Paper - Securing Our Water Future Together (2004) pg 94.

4 Melbourne City Suburbs Economic and Demographic Profile 2003

5 Refer to Melbourne City Suburbs Economic and Demographic Profile 2003 for comprehensive details.

6 Refer to Total Watermark 2004, Section 6.1.2, page 14.

7 Water consumption figures are provided by Watermark 2003 and based on 1999 statistics.

8 Melbourne Water (1997) Annual Stream Health Monitoring Project 1997 - Health of Waterways within the Port Phillip and Western Port Catchments

9 Melbourne Water (www.melbournewater.com.au) and City West Water (www.citywestwater.com.au)

11 NSW Health (2000) Greywater reuse in sewered single domestic premises

12 Refer Victoria EPA (2001) Reuse options for household wastewater - publication 812

13 Department of Human Services (2003) Appropriate reuse of greywater

14 Refer to Crites and Tchobanoglous (1998) Small and decentralised wastewater management systems, McGraw-Hill.

15 Phosphorous removal is dependent on the reactor configuration and the scale of treatment system.

16 Further pathogen removal, such as disinfection may be required to meet EPA Victoria requirements.

17 Pollutant removal by membrane filtration is a physical separation process with pollutant removal dependent on the pore size, refer to fact sheet 15

18 Metcalf and Eddy (2003) Wastewater engineering - treatment and Reuse, Fourth Edition, McGraw-Hill - pg 191.

19 EPA Victoria's Guidelines for Environmental Management: Use of Reclaimed Water - Publication 464.2, 2003.

20 Refer to Melbourne Water (www.melbournewater.com.au)

21 Refer to 60L - the Green Building (www.60lgreenbuilding.com)

22 Metcalf and Eddy (2003) (2003) Wastewater engineering - treatment and Reuse, Fourth Edition, McGraw-Hill - pg 191.

23 *Total Watermark 2004* refer to page 23.

24 Refer to Drainage Plan - 2004 - 2009 - Section 127 and 128 (pg 24) and Implementation items 28 - 32

25 For more details - www.catchment.crc.org.au

26 EPA Victoria's Guidelines for Environmental Management: Use of Reclaimed Water - Publication 464.2, 2003.

27 EPA Victoria's Guidelines for Environmental Management: Use of Reclaimed Water - Publication 464.2, 2003.

28 Lloyd, S.D., Wong, T.H.F. and Chesterfield, C.J. (2002), Water Sensitive Urban Design - A Stormwater Management Perspective, Industry Report 02/10, Cooperative Research Centre for Catchment Hydrology, ISBN 1 876006 91 9, 38p.

Section Two - Scenarios for the City of Melbourne

1 Data supplied by RMIT

2 Design development report of rainwater harvesting project, Rimmington & Associates Pty Ltd, March 2003.

3 Docklands authority concept vision - www.docklands.com

4 *Total Watermark 2004*, Figure 13, page 15.

5 Refer to Table 6 (page 36) in *Total Watermark 2004*.

6 Based on a four hour visit per person and proportioning daily toilet usage of 22L/day, assuming 650,000 visitors as reported in 2003.

7 City West Water - Water Management Plant, Queen Victoria Market Pty Ltd, Preliminary Report 2004.

8 Refer to Table 6 (page 36) in *Total Watermark 2004*.

9 Austral Archaeology: conservation policy for old Melbourne Cemetery- Queen Victoria Market - Master plan 2003

10 City West Water - Water management plan, Queen Victoria market Pty Ltd, Preliminary report - 15 June 2004

11 Refer to Rocla's website www.waterquality.rocla.com.au for additional information.

12 Assuming an average shower is 5 minutes with AAA fitted shower nozzles at 37.5 degrees C, a 50% mix of cold and water is required with an average 15 degrees C cold water and hot water delivery at 60 degrees C. Average shower uses 22-25L/person/day of hot water and an average usage of 80 showers per day has a 2000L/day.

13 Assuming toilet demand is 400L/day and roof ara is 386m2 = 103 L per 100m2.

14 Refer to Table 6 (page 36) in *Total Watermark 2004*.

Section Three - Fact Sheets

1 Department of Human Services (2003) Appropriate reuse of greywater

2 Refer to Melbourne Water (www.melbournewater.com.au)

3 Refer to 60L - the Green Building (www.60lgreenbuilding.com)

4 EPA Victoria's Guidelines for Environmental Management: Use of Reclaimed Water - Publication 464.2, 2003.