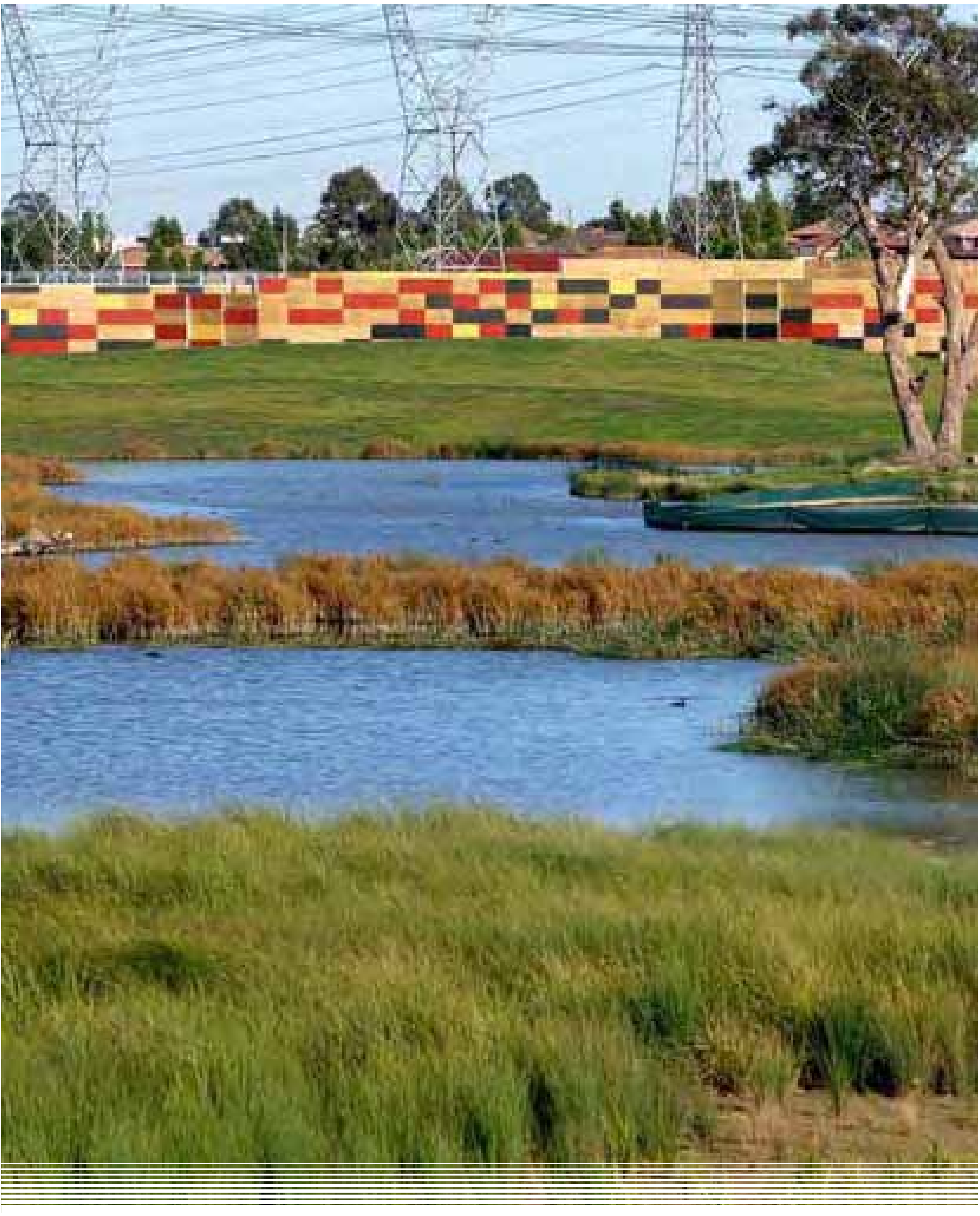
Council Name
WSUD Guidelines

Applying the Model WSUD Guidelines

An Initiative of the Inner Melbourne Action Plan

ADD LOGO



Contents

Executive Summary

Water Sensitive Urban Design (WSUD) embraces a range of measures that are designed to avoid, or at least minimise, the environmental impacts of urbanisation in terms of the demand for water and the potential pollution threat to natural water bodies.

The *Model WSUD Guidelines* inform Council staff, developers and residents on how to apply WSUD principles to urban developments or local water reuse and treatment projects.

These 'model' guidelines are available for Councils to adapt and adopt as their own.

Part One – WSUD Policy Commitment

Module 1.1 – Local context

Local government is committed to sustainable water management to conserve water, improve waterway health and protect groundwater.

Module 1.2 – Melbourne's Urban Water System

Greater Melbourne is experiencing prolonged drought and requires a range of solutions at both the metropolitan and municipal scale to deliver water supply security and improved waterway health.

Module 1.3 – WSUD Guiding Principles

Sustainable water management needs to bring together water conservation, stormwater quality, wastewater reductions and groundwater quality to achieve the best long term results for Melbourne. WSUD provides the approach and tools to deliver these goals on the ground.

A sustainable water management hierarchy is set out that encompasses the city as a catchment approach of managing water within the local area before drawing from beyond local boundaries.

As a principle, all water saving projects should encompass stormwater treatment measures and vice versa.

Current best practice performance objectives are:
- 80% reduction in Total Suspended Solids
- 45% reduction in Total Nitrogen
- 45% reduction in Total Phosphorous
- 70% reduction in litter from typical urban loads.

Module 1.4 – Legislation and Policy Framework

There are an increasing range of Federal, State, regional and local legislative and policy requirements that apply to sustainable water management.

Part Two – Getting WSUD On The Ground

Module 2.1 – Starting the Project

To achieve the best results, set clear objectives. Consider existing targets associated with environmental, economic and social outcomes needed for your organisation. Visit your site and undertake a 'water balance' to understand it more holistically. Use the handy WSUD Checklist at this early stage.

Module 2.2 – Scoping WSUD Options

There are a range of different WSUD treatments available to use. Use the sustainable water management hierarchy to consider options for a site. Firstly reduce water demand, then consider rainwater harvesting, stormwater harvesting and water recycling. Beyond this, water can be sourced beyond the immediate surrounds. Alternative water sourcing projects can be measured for improvements to stormwater quality and further enhanced where possible.

Stormwater quality works can be modelled to show how different solutions and treatment trains can contribute to local stormwater quality targets and hence waterway health improvements.

Module 2.3 – Considering Environmental Impacts

Sustainable water projects delivered through WSUD need to provide a net environmental benefit.
Be sure to avoid or mitigate any biosolids, sodicity, salinity, nutrient, odours and greenhouse gases that could arise from projects if not planned carefully.

Module 2.4 – Being Carbon Sensitive

Be sure to model the greenhouse gas emissions that could occur from different WSUD treatments.
These could be emitted from energy use, biological processes or through embodied energy. Use our specially developed Carbon Calculator for WSUD Treatments to model the emissions and follow our more detailed WSUD Carbon Sensitive Framework to 'neutralise' emissions.

Module 2.5 – Considering Life Cycle Costs

Assess the financial implications of a WSUD project by considering the full life cycle costs. This will take into account capital expenditure, installation, operation, ongoing maintenance and labour costs, replacement costs and timing for significant expenditure, life span, and decommissioning costs.

Module 2.6 – Assessing the Risks

Protecting public health and the environment is paramount when alternative water sources are being used. Careful planning, construction and monitoring are required to make sure reused water is safe. Use the more detailed WSUD Risk Management Guidelines with its straightforward risk management for simple projects, and a comprehensive approach for more complex projects and those that carry higher risks.

Module 2.7 – Site Design and Approvals

Water sensitive urban design can be integrated into the design and construction of different urban development sites, large and small. Consider a range of ideas and applications whilst taking into account approvals and compliance issues.

Module 2.8 – Maintaining WSUD Assets

Plan and fund for maintenance to ensure the projects goals are met over the long term.

Part Three – Case Studies

These case studies help show how WSUD can be implemented.

Part Four – Fact Sheets

For further detail, refer to these fact sheets covering everything from rainwater tanks to wetlands to gross pollutant traps. If you are still seeking further detail, go to the State Government's Engineering Procedures Manual.

Part Five – Supporting Documents

Part Six – Glossary

And to be sure we are talking the same language, here is a WSUD glossary.

Part 1
WSUD Policy Commitment

Module 1
Introduction

Leadership and commitment

Insert a paragraph describing how Council is committed to providing leadership in sustainable water management and how it is working with others to demonstrate WSUD principles in action.

Purpose of the *WSUD Guidelines*

The *WSUD Guidelines* inform Council staff, developers and residents on how to apply Water Sensitive Urban Design (WSUD) principles to urban developments or local water reuse projects.

These guidelines provide information, strategic advice and practical tips on implementing WSUD in a structured way.

Choose how the guidelines will be used in your municipality

WSUD guiding principles

WSUD embraces a range of measures that are designed to avoid, or at least minimise, the environmental impacts of urbanisation in terms of the demand for water and the potential pollution threat to natural waterways.

WSUD recognises that all water streams in the urban water cycle are a resource, not just drinking water. This includes:

- Rainwater
- Stormwater
- Potable mains drinking water
- Greywater (water from the bathroom sinks, shower, and laundry)
- Blackwater (toilet and kitchen)
- Water mining (sewer).

The following goals of WSUD will be explained in detail in this guide:

- Reduce potable water consumption
- Maximise water reuse
- Reduce wastewater discharge
- Minimise stormwater pollution before it is discharged to the aquatic environment
- Maximise groundwater protection.

Structure of the *WSUD Guidelines*

The guidelines have six parts. Each part is broken down into a series of modules that cover specific topics.

Part 1 is aimed at Council staff and covers the policy commitment needed to achieve WSUD. It introduces the principles of WSUD, with a focus on integrated water cycle management. It also covers the legislation and policy framework surrounding WSUD at Council, State and Federal level.

Part 2 is aimed mainly at Council designers and developers. It explains how to implement a WSUD system through a project management framework. The modules cover design, risk, climate change impacts, construction and maintenance. Householders may also be interested in some of these modules if they are thinking about building or retrofitting a water reuse project.

Part 3 showcases the practical application of WSUD through a series of case studies spanning the breadth of local demographics and stakeholders. Examples demonstrate innovative and practical applications of WSUD principles through different building types found within the Council area.

Part 4 includes a series of fact sheets to help people understand WSUD elements and treatment technologies.

Part 5 includes a list of supporting documents and tools that can be used to assist you in implementing water sensitive urban design.

Part 6 includes a WSUD glossary and other sources of information.

Part 1
WSUD Policy Commitment

Module 1.2
Melbourne's Urban Water System

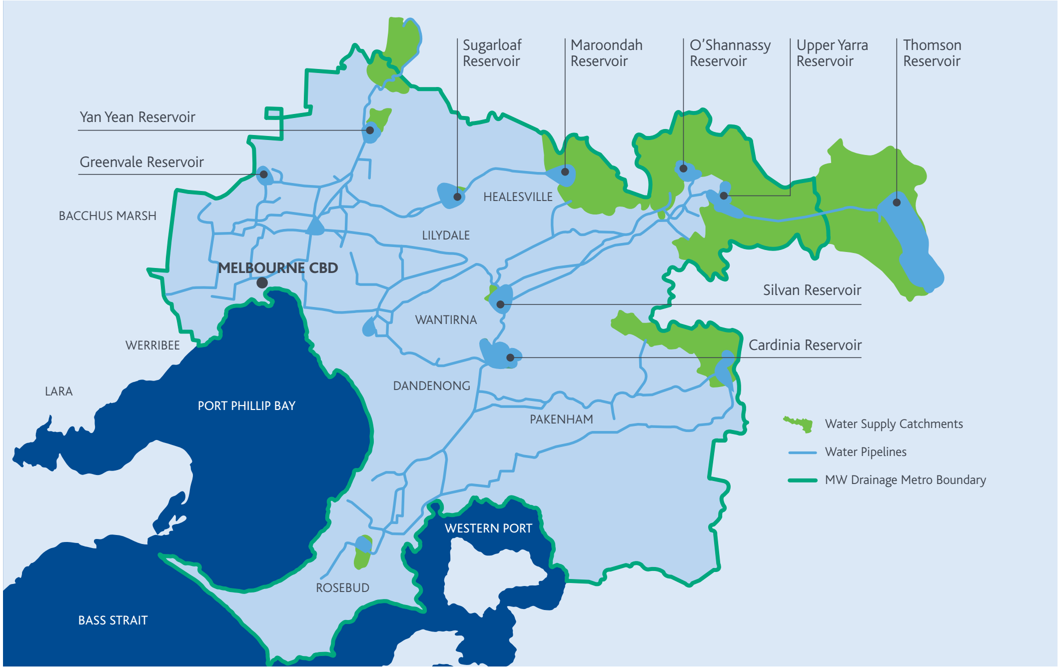
Greater Melbourne

Melbourne's water is sourced from catchments to its north and east, mostly in the Yarra Ranges. The water quality is high because the catchment is mainly natural forests in pristine condition. The water is stored in nine reservoirs (Thomson, Upper Yarra, O'Shannassy, Maroondah, Sugarloaf, Yan Yean, Greenvale, Silvan and Cardinia reservoirs) as shown in Figure 1.

The water is treated to meet drinking water standards. The majority (90%) needs minimal treatment because the catchment is pristine catchment. The remaining 10% needs filtering.

The treated water is piped to the urban area shown in Figure 1. This water is used for a range of purposes. Only a small fraction (approximately 4%) is used for human consumption.

Figure 1. Water supply catchment and main water pipelines for Melbourne (Melb Water[1])



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[1] Melbourne Water http://www.melbournewater.com.au/ date accessed 1/08/06

Wastewater is collected by a separate network of underground pipes to the Western (Werribee) and Eastern (Bangholme) treatment plant. Sewage can take as long as 12 hours to reach the Treatment Plants. Once treated, effluent from the Western Treatment Plant is discharged to Port Phillip Bay and the Eastern Treatment Plant to Bass Strait.

Melbourne's water businesses are on track to meet government targets of 20% recycling of effluent by 2010. An additional water recycling target of 30GL of new potable substitution projects by 2030 is also in place, with new recycling schemes being developed and implemented to meet this goal.

Rainfall on urban catchments (urban stormwater) is collected by a separate network of underground pipes. The majority of the catchment area discharges directly to Port Phillip Bay or nearby receiving waters that eventually discharge to the Bay.

Melbourne's geology is primarily a basalt shelf. It is not well suited to groundwater extraction, with the water quantity and quality being typically low and saline.

City of Council Name

Insert information on:

- The City's catchment area
- Demographics and characteristics
- The City's water consumption – broken down into users
- Water saving targets

Demographics and characteristics

Insert relevant information

The city’s water consumption

Insert information on the City’s water quality, including assessments of waterways for chemical tests, biological tests, stream life and vegetation

Rainfall patterns and water storage volumes

Melbourne has a relatively dry climate with an average evaporation of 3.4mm per day, or 1241mm per year. Melbourne’s average annual rainfall is approximately 650mm[2]. Rainfall pattern is remarkably even, with the lowest month (February) having 45 mm and the highest month (October) having 65mm.

The current drought has highlighted the importance of water to the economy, community and environment. For more than 10 years, a large part of Victoria has struggled with rainfall significantly below the long-term average. Its severity has been unprecedented, and its impact has been widespread across the State.

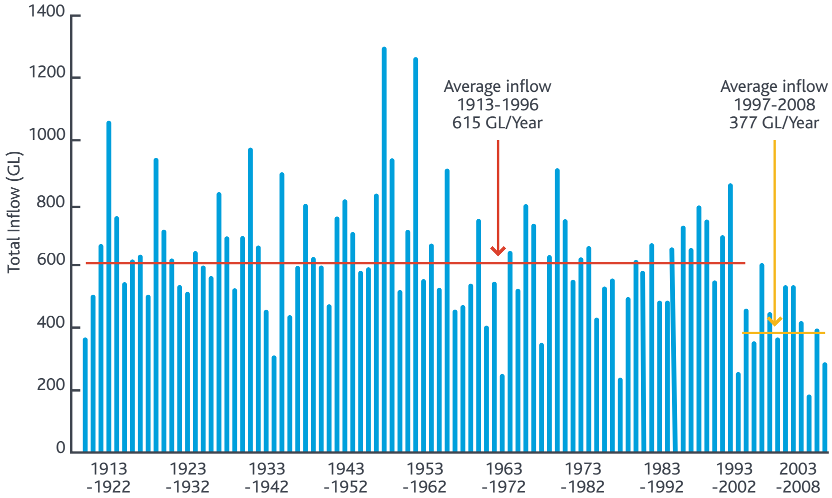
For Melbourne, inflows into our water storages over the past 10 years present a similar picture. Melbourne and surrounding centres had relatively reliable rain for one hundred years, until the mid 1990s. This was the basis for confident planning of future water supplies. However the situation has changed and the past decade has been one of sustained drought.

In 2006, inflows to Melbourne Water’s major water storages were the lowest on record. Average inflows to Melbourne’s four major harvesting storages for the period 1997/98 to 2006/07 were about 35% less than the long term average (1913/14 to 2006/07), as shown in Figure 2. Melbourne’s water storages have a total capacity of 1,773,000 megalitres.

Questions about the impact of climate change on our water resources have been prompted by the severity of the drought over the past 10 years. It is possible that Victoria is suffering a major long-term reduction in average rainfall – a step-change in water availability due to climate change.

[2] Australian Government Bureau of Meterology Climate Statistics for Melbourne 2008

Figure 2. Melbourne Average Annual Inflow 1913 to 2008



Water management drivers

There are a number of inter-related drivers for sustainable management of water resources. Water supply, demand, quality and transport are all driven by and influenced by:

- Population
- Climate change and human health
- Environmental impacts.

Melbourne's demand for water is increasing with population growth. At the same time, changing climatic patterns and environmental flow commitments of water supply catchments could reduce water availability.

Port Phillip Bay received the city's stormwater and treated wastewater. This means that the Bay's aquatic ecology is inherently linked to this water. Integrated water management solutions are needed to keep our ecosystems healthy through secure and reliable water supply and appropriate water control and treatment.

Insert the key issues for sustainable water management practices

The City's water quality

Insert information on the City's water quality, including assessments of waterways for chemical tests, biological tests, stream life and vegetation

Part 1
WSUD Policy Commitment

Module 1.3
WSUD guiding principles

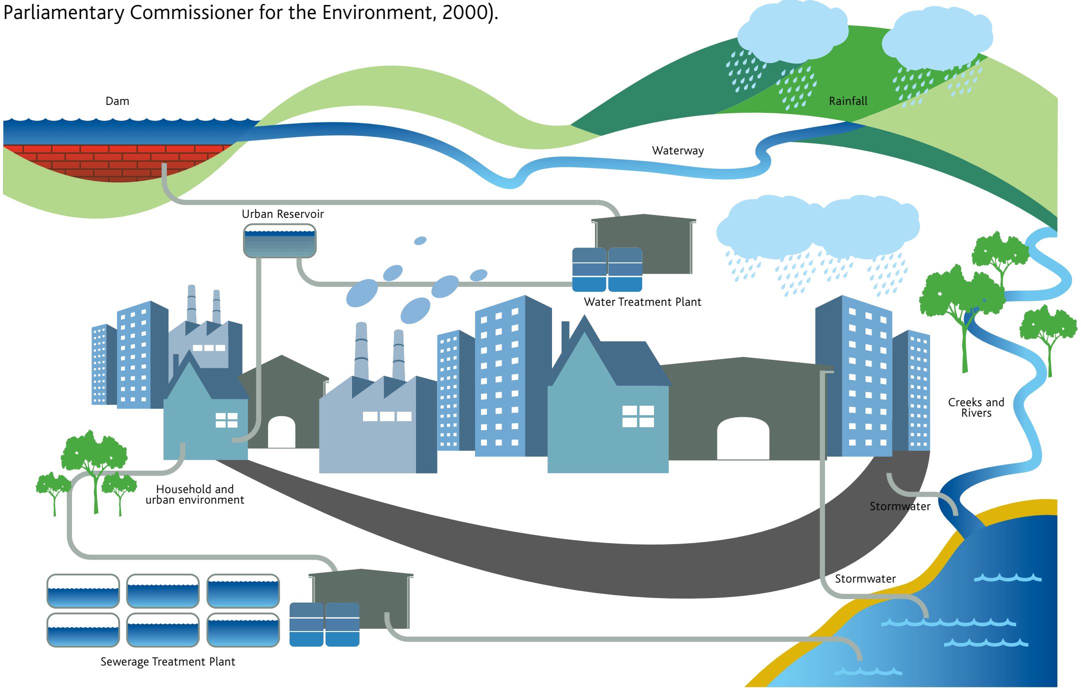
Conventional urban water management

There are three separate water systems operating in Melbourne's urban areas:

- Potable mains water supply – piped system treating and delivering drinking quality water from catchments outside of the urban area
- Sewerage system – piped system collecting and transporting residential and commercial wastewater to treatment plants before it is discharged to Port Phillip Bay and Bass Strait
- Stormwater system – natural flowpaths, waterways and underground piped systems transporting stormwater and other natural sources of water to Port Phillip Bay and Westernport Bay.

These artificial systems sit within the natural catchment system and are shown in Figure 3.

Figure 3. Illustration of a conventional urban water cycle
(adapted from a figure contained in the report by the New Zealand Parliamentary Commissioner for the Environment, 2000).



Traditionally, urban water management in Australia has primarily meant:

- Quickly moving urban stormwater to the nearest natural waterway for flood protection
- Safely removing and treating wastewater through centralised infrastructure
- Supplying safe, good quality drinking water through centralised piped infrastructure.

WSUD marks a shift in thinking towards integrated water management where all water streams are considered a resource. The integrated water management cycle considers:

- Rainwater
- Stormwater
- Groundwater
- Potable mains drinking water
- Greywater (water from the bathroom taps, shower, and laundry)
- Blackwater (toilet and kitchen)
- Water mining (sewer).

Managing the city as a catchment

All city sites, including buildings, roads, footpaths and open space can contribute to sustainable water resource management across the municipality. This means that water can be increasingly managed from the local catchment and rely less on external catchments. For example:

- Roads can be sources of water via stormwater harvesting
- Buildings can be sites for reducing stormwater pollution through rain gardens.

Over time, this approach will build the resilience of water resources and aquatic environments under the pressures of urban consolidation and climate change.

Community engagement is an integral component of all projects, from the project conception onwards.

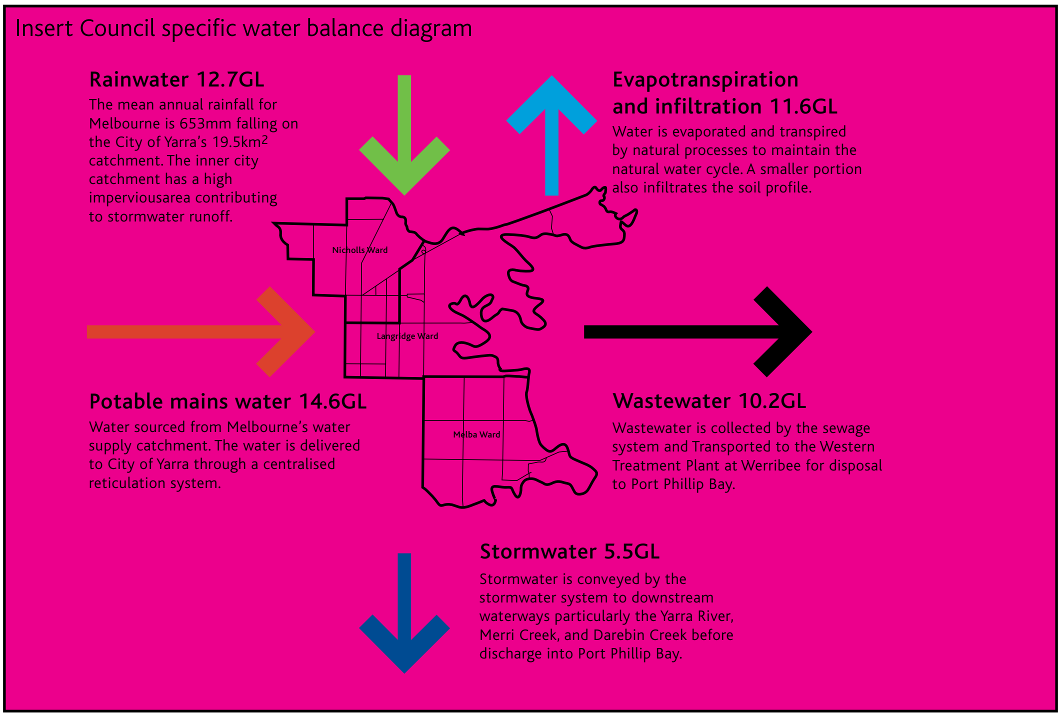
Incorporating local, decentralised solutions that are 'sensitive' to the issues of water and energy sustainability for environmental protection is a fundamental part of achieving community engagement.

All city sites, planning or building proposals, and council managed projects need to:

- Identify a site as a water source or sink (that is, a site water budget) and identify opportunities on the site itself and on nearby sites that could use surplus water or provide deficit water
- Account for costs and benefits of decentralised water options in terms of water, energy, building materials/infrastructure/technology, and risks
- Consider habitat enhancement for biodiversity, birdlife and microclimate benefits.

The guiding principles below promote the adoption of sustainable water management practices across council managed assets, residential and commercial/industrial land uses. These align with the WSUD options discussed in Part 2 of these guidelines.

Council Name as a Catchment



Insert Council specific water balance diagram

Rainwater 12.7GL

The mean annual rainfall for Melbourne is 653mm falling on the City of Yarra's 19.5km^2 catchment. The inner city catchment has a high imperviousarea contributing to stormwater runoff.

Evapotranspiration and infiltration 11.6GL

Water is evaporated and transpired by natural processes to maintain the natural water cycle. A smaller portion also infiltrates the soil profile.

Potable mains water 14.6GL

Water sourced from Melbourne's water supply catchment. The water is delivered to City of Yarra through a centralised reticulation system.

Wastewater 10.2GL

Wastewater is collected by the sewage system and Transported to the Western Treatment Plant at Werribee for disposal to Port Phillip Bay.

Stormwater 5.5GL

Stormwater is conveyed by the stormwater system to downstream waterways particularly the Yarra River, Merri Creek, and Darebin Creek before discharge into Port Phillip Bay.

WSUD guiding principles

WSUD seeks to achieve integrated water management by:

- Reducing potable water consumption
- Maximising water reuse
- Reducing wastewater discharge
- Minimising stormwater pollution before it is discharged to the aquatic environment
- Maximising groundwater protection.

These principles are achieved through:

- Managing the demand for water by reducing it
- Assessing the appropriate potable or alternative supply of water for the end purpose
- Applying best practice to stormwater management.

Integrated water cycle management matches available water sources with the most appropriate uses ("fit-for-purpose"). This is a way to reduce the demand on the highest quality potable mains water.

Drinking quality water isn't needed for uses such as irrigation and toilet flushing and alternative sources (possibly from reuse) should be found. For example, in Melbourne there are three major water sources:

Potable mains water

drinking water

Water harvesting

Rainwater (roofs)

Stormwater (surface runoff including roads, parks, footpaths)

Wastewater

greywater (bathroomand laundry)

blackwater (toilet and kitchen)

water mining (sewer)

WSUD in highly built up urban environments

It's commonly thought that WSUD is only effective in large 'greenfield' sites because of the limited space available in the inner city. However research and experience show that inner urban areas contribute to stormwater pollution and therefore have an equal responsibility to improve water quality.

The continued regeneration of our city provides an ongoing opportunity to continually improve water quality measures. WSUD elements can be designed to various scales, and treatment can be applied to any site. WSUD can be continuously incorporated into Melbourne's cityscape during urban regeneration and renewal works.

In Module 2.2, a *sustainable water management hierarchy* is set out to help users step through the WSUD options available for different sites (such as rainwater, stormwater and water recycling).
The hierarchy applies a general preference:

- To reduce pollution at the same time as reducing potable water demand
- To use smaller, localised and modular treatment technologies over a reliance on a single, large and centralised treatment facility covering much of the metropolitan area and
- To protect the environment by minimising greenhouse emissions and other forms of pollution.

How does WSUD relate to other concepts?

'Water Sensitive Urban Design' (WSUD) is often confused with the terms 'Ecologically Sustainable Development (ESD)' and 'Water Cycle Management' (WCM). The three terms are distinct but linked, as shown in Figure 4.

ESD is the environmental component of sustainable development that maintains and protects ecological processes. WSUD sits under ESD as an application of its themes into the urban design area. WSUD is considered in the area of urban design and built form, integrating and protecting all aspects of the urban water cycle.

Figure 4. Interactions between ESD, WSUD and the Urban Water Cycle[3]

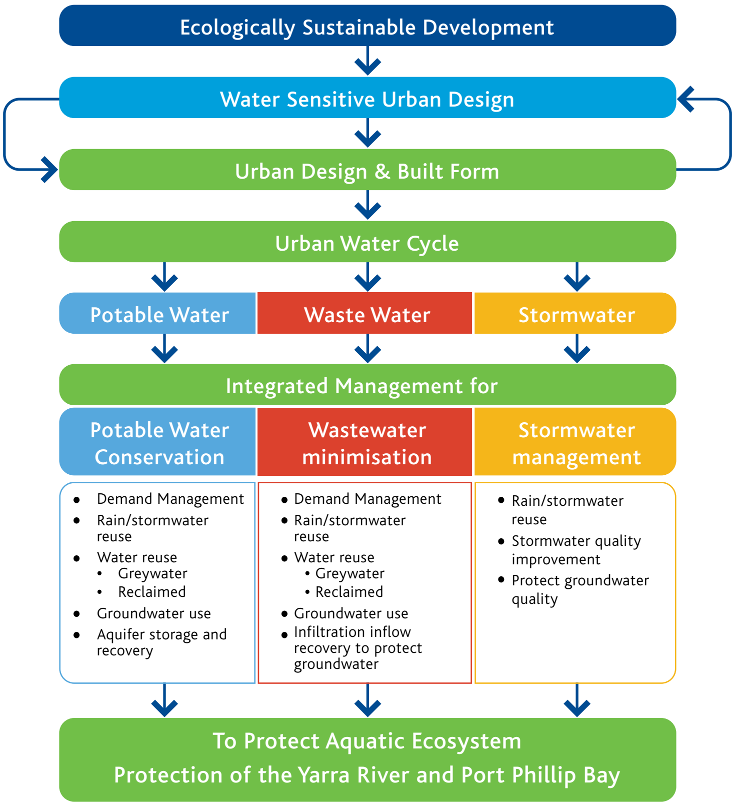


Figure 4. Interactions between ESD, WSUD and the Urban Water Cycle shows the close relationship between WSUD elements. Often links between the urban water streams are developed when one element is adopted, for example rainwater harvesting will conserve potable mains water and reduce stormwater discharges.

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[3] Ecological Engineering (2005) Landcom's Water Sensitive Urban Design strategy

There are numerous ways to incorporate WSUD in a redevelopment project to meet water targets. Strategies depend on factors such as:

- Individual site conditions (e.g. location, geography)
- Building function and occupancy (e.g. residential, commercial, industrial)
- Development or redevelopment scale
- Water use and demand (e.g. garden irrigation demand, industrial use)
- Water sources available, including local climate (rainfall seasonality)
- On-site catchment area (roof and surface)
- Urban landscape design (architectural and landscape).

To produce an innovative and optimal solution, the WSUD approach will need input from a range of disciplines, including architects, landscape architects, engineers, planners, regulators, maintenance personnel and local community members with an appreciation of WSUD.

Benefits of WSUD

WSUD benefits the environment in a number of ways including:

- Increased water conservation
- Improved stormwater quality, therefore improved water quality in waterways, bays and catchments
- Improved habitat and biodiversity through the establishment of wetlands and other 'natural' treatment alternatives
- Reduced greenhouse gas emissions by reducing water consumption and increasing rainwater harvesting and 'natural' treatment alternatives.
- Providing an adoption measure to address climate change impacts such as flooding and heat island effect.

The urban setting also benefits in a number of ways including:

- Replacement of pipes with natural elements for drainage, such as wetlands
- Enhanced aesthetics through increased vegetation, aquatic elements and landscaping
- 'Visible infrastructure' combining functionality and natural elements
- Linked urban and natural environments
- Flood mitigation by slowing down water movement through urban areas to streams.

Part 1
WSUD Policy Commitment

Module 1.4
Legislation and Policy Framework

Water Sensitive Urban Design (WSUD) and the principles of sustainable water management are supported by the Commonwealth, Victorian and local Governments. This section covers the main legislation and policy tools related to WSUD principles and associated targets set by Council. It also includes a list of relevant codes, standards and guidelines from EPA Victoria and Standards Australia.

Council Name legislation and policy framework

Insert Council policies and strategies relevant to WSUD principles. Include strategies and policies and any relevant targets relating to stormwater management, water reduction, wastewater, groundwater and water reuse.

Federal Government legislation and policy framework

This section covers the main Victorian and Federal legislation and policy tools relevant to WSUD principles. This can be incorporated into WSUD Guidelines as an appendix for further reference. Please amend for your own Council.

The National Water Initiative (NWI)

The NWI is Australia's blueprint for national water reform and was signed by the Council of Australian Governments (COAG) between 2004 and 2006. The National Water Commission is the body responsible for driving water reform at the national level and has accredited the Victoria Implementation Plan.

The NWI is made up of approximately 70 actions. One of its expected outcomes is "better and more efficient management of water in urban environments, for example through the increased use of recycled water and stormwater".

Victorian Government legislation and policy framework

***Environment Protection Act 1970* (the Act)**

Administered by the Environment Protection Authority (EPA), the Act aims to protect the environment from pollutants by limiting activities of industry and business to an environmentally acceptable level. This is done through primary mechanisms such as licensing, works approvals, inspections, pollution abatement notices and land use planning referrals.

The Act assists policy development, for example State Environment Protection Policies. Specific requirements have been developed by EPA including:

- Best Practice Environmental Guidelines for Major Construction Sites Publication No. 480
- Construction Techniques for Sediment Pollution Control – Publication No. 275.

State Environment Protection Policies (SEPPs)

A SEPP:

- Sets out the beneficial uses and values of the environment
- Defines environmental quality objectives
- Describes the attainment and management programs that will ensure the necessary environmental quality is maintained.

Most relevant to the Council name and the management of its stormwater are:

- *SEPP (Waters of the Port Phillip Bay)* – Schedule F6 defines requirements for nutrient management within Port Phillip Bay
- *SEPP (Ground Waters of Victoria)* also sets out requirements for protecting groundwater
- *SEPP (Waters of Victoria)*.

Local Government Act 1989

The *Local Government Act 1989* gives Victorian Councils the power to create local laws to assist in delivering democratic, efficient and effective local government. Particular reference to the protection of stormwater is contained within the *Environment Local Law 1999* and the *Activities Local Law 1999*.

Local laws

Councils have various responsibilities and powers under both State and Federal laws. Where appropriate, councils may make local laws to exercise these powers.

Local laws are often adopted to protect public health, safety or amenity in a municipality. They are designed to stop the actions of an individual or group having a negative or undesirable impact on the rest of the community.

Local laws only apply within a particular municipality and complement or implement other legislation.

They often deal with waste and stormwater management issues.

Insert relevant local laws

Building Act 1993

The *Building Act 1993* controls the safety and quality of building works. Under Part 2 Section 8 of the Act, Council has the power to make local laws with respect to requirements for building work and the preparation of land for building works.

However the Act does not make any specific reference to environmental matters and Council has no obligations under this legislation to consider stormwater management.

Planning and Environment Act 1987

The *Planning and Environment Act 1987* provides a "framework for planning the use, development and protection of land in Victoria in the present and long term interests of all Victorians". The framework requires planning to encompass and integrate relevant environmental, social and economic factors.

Council has an obligation (as a planning authority and responsible authority) to:

- Administer the Act
- Consider the potential impacts that land uses and developments may have on stormwater discharges.

State Planning Policy Framework

The State Planning Policy Framework provides a context for spatial planning and decision making by planning and responsible authorities. It contains a statement of general principles for land use and development planning and specific policies dealing with sectoral issues.

The clauses related to WSUD principles include:

- Clause 11.01 – net community benefit and sustainable development
- Clause 11.03 – adopt a best practice environmental management and risk management approach
- Clause 12.07 – manage water resources, reduce the impact of stormwater on bays and catchments using stormwater management (Melbourne 2030)
- Clause 14.01 'Settlement' – "Decision making by planning and responsible authorities must be consistent with any relevant requirements of State environment protection policies as varied from time to time, including the Air Environment, Waters of Victoria and specific catchment policies…"
- Clause 15.01 – decision-making to be consistent with SEPP (Waters of Victoria and specific catchment policies)
- Clauses 15.01 and 18.09 – consideration of Urban Stormwater Best Practice Environmental Management Guidelines.

Clause 56 for residential subdivisions

Clause 56.07 of the State Planning Policy is a new provision introduced in October 2006. It requires new residential subdivisions of two lots or more to meet best practice water flow and treatment requirements and incorporate integrated water management principles.

Clause 56.07 requires the provision of:

- Drinking water systems, waste water systems and urban stormwater management systems to the boundaries of all lots, where required by the relevant water authority, sewerage authority or drainage authority
- Reused and recycled water systems to the boundary of all lots, where a site is in one of the areas where the water authority requires a dual water reticulation system. Reused and recycled water systems could be provided in other locations where agreed by the relevant water authority.

Clause 56.07 has the following provisions:

- 56.07-1 Drinking water supply objectives and Standard C22
- 56.07-2 Reused and recycled water objective and Standard C23
- 56.07-3 Wastewater management objective and Standard C24
- 56.07-4 Urban run-off management objectives and Standard C25.

The specific objectives of Clause 56.07-4 are to:

- Minimise damage to properties and inconvenience to residents from urban run-off
- Ensure that the street operates adequately during major storm events and provides for public safety
- Minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off.

Standard C25 sets out the normal way to meet the objectives of Clause 56.07-4. Among other requirements, Standard C25 requires that urban stormwater management systems 'must' be designed to:

- Meet current best practice performance objectives for stormwater quality, as outlined in the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999) as amended
- Ensure that flows downstream of the subdivision site are restricted to predevelopment levels unless increased flows are approved by the relevant drainage authority and there are no detrimental downstream impacts.

Standard C25 requires that urban stormwater management systems must be designed and managed to the requirements of the relevant drainage authority. This authority is typically Council, with the exception of catchments of 60ha or more within the Melbourne Water drainage boundary, when it is Melbourne Water.

Clause 54 and 55 for residential development

Clause 54.03-4 and 55.03-4 set permeability objectives and standards to reduce the impact of increased stormwater runoff on the drainage system and to facilitate on site stormwater filtration through the design and use of open and permeable spaces. The standard requires that at least 20% of the surface should not be covered by impermeable surfaces. Decision guidelines for assessing an application include a site specific design response, consideration of existing conditions, the capacity of the drainage network, the capacity of the site to absorb runoff and the practicality of achieving 20% coverage of pervious surfaces on a site less than 300 sqm. At the discretion of the Council the standard in Clause 54 can be varied through a schedule to a zone or overlay in the planning scheme.

The Municipal Strategic Statement (MSS)

The MSS is a statement of the key strategic planning, land use and development objectives for municipalities. It provides the strategic basis for:

- The application of the zones, overlays and particular provisions in the planning scheme
- Decision-making by the responsible authority.

Objectives of the MSS relate to improving water quality and enhancing environmental values of local water bodies.

Melbourne 2030 – planning for sustainable growth

Melbourne 2030 is a 30-year plan to manage growth and change across metropolitan Melbourne and the surrounding region. It was released in October 2002.

The Metropolitan Strategy sets objective for water management in two policies:

- Policy 7.1
- Policy 7.4.

Policy 7.1 "ensures that water resources are managed in a sustainable way". It sets out broad objectives on how to achieve this including the promotion of water efficiency practices and adopting guidelines to encourage the use of alternative water sources such as rainwater tanks and water recycling.
Targets have been set for:

- 15% per capita reduction in water consumption by 2010
- An increase in waste-water recycling from 1% to 20% by 2010 for non-potable uses such as in agriculture, industry and recreation.

Policy 7.4 "reduces the impact of stormwater on bays and catchments". Water sensitive urban design and groundwater management are promoted in this policy. A goal of 20% of waste water at the treatment plants is to be recycled by 2010. Targets are also set for stormwater quality including:

- 45% reduction in nitrogen load
- 45% reduction in phosphorus load
- 80% reduction in suspended solid loads.

Melbourne @ 5 million is the 2008 update on projections contained within Melbourne 2030. It forecasts that Melbourne will reach 5 million before 2030, growth figures which will need to be considered when implementing the Strategy's objectives for water management.

Securing Our Water Future Together

Securing Our Water Future Together is a white paper that was released in June 2004. It sets out 110 actions to secure Victoria's water future for the next 50 years covering reform in all aspects of water management – water allocation, markets, urban demand and supply, meeting environmental needs, pricing and institutional reform.

As part of the Our Water Our Future action plan, four regional Sustainable Water Strategies are being created to plan for water security across Victoria. Each Sustainable Water Strategy sets out a long-term regional plan to supply water for local growth, while maintaining the balance of the area's water system and safeguarding the future of its rivers and other natural water sources.

Each regional Sustainable Water Strategy will:

- Provide a stock-take of all the water resources available within a region
- Outline the planning and actions needed to ensure we have secure and affordable water for our communities, business, industry and the environment into the future.

The strategies are being developed by the Department of Sustainability and Environment in partnership with Catchment Management Authorities, Rural and Urban Water Authorities, and their key regional stakeholders and communities.

The four regional strategies cover:

- Northern Victoria Region (the River Murray system and its tributaries – Loddon, Goulburn, Broken, Campaspe, Kiewa and Ovens systems) – Discussion paper written in February 2008
- Central Region (West Gippsland, Port Phillip, Westernport, Western, Central Highlands and Barwon Regions) – Strategy written and individual plans developed
- Western Victoria – to be developed
- Eastern Region (Gippsland) – to be developed.

Yarra River Action Plan

The Yarra River Action Plan was launched by the Victorian Government in 2006 and outlines:

- Projects that will meet the challenge of managing water quality in the Yarra River over the long-term
- How the Government will protect and improve the health and amenity of the Yarra
- How the community can get involved in the process.

Government priority projects include:

- Tackling sources of pollution
- Monitoring and communicating the health of the river
- Involving the community
- Healthy river flows
- Managing river water quality.

Victorian River Health Strategy (VRHS)

The Victorian River Health Strategy (VRHS) was released in August 2002. It outlines the Government's long-term direction for the management of Victoria's rivers. It provides:

- A clear vision for the management of rivers in Victoria
- Comprehensive policy direction on issues affecting river health
- A blueprint for integrating all our efforts on rivers and for ensuring that we get the most effective river health benefits for the effort and resources invested.

The VRHS provides the framework for regional communities to make decisions on river protection and restoration and to find the balance between using our rivers and maintaining their ecological condition.

It has been developed in close consultation with key stakeholder groups.

Codes, standards and guidelines relevant to WSUD

NWQMS (2006) Document 21: *Australian Guidelines for Water Recycling – Managing Health and Environmental Risks (Phase 1)*

NWQMS (2009) Document 23: *Australian Guidelines for Water Recycling – Stormwater Harvesting and Reuse*

DHS Victoria (2007) *Rainwater Use in Urban Communities: Guidelines for Non-drinking Application in Multi-Residential, Commercial and Community Facilities*

DSE Victoria (2007) Publication DSE0603: *Rainwater Use in and Around the Home*

EPA Victoria (2006) Publication 384: *Enforcement policy*

EPA Victoria (2003) Publication 464.2: *Guidelines for environmental management: Use of reclaimed water*

EPA Victoria (1997) Publication 500: *Code of practice for small wastewater treatment plants*

EPA Victoria (2008) Publication 865.7: *Environmental auditor guidelines for appointment and conduct*

EPA Victoria (2008) Publication 884.1: *Greywater Use Around the Home*

EPA Victoria (2008) Publication 891.2: *Code of Practice: Onsite Wastewater Management* (under review)

EPA Victoria (2007) Publication 952.2: *Environmental auditor guidelines for the preparation of environmental audit reports on risk to the environment*

EPA Victoria (2007) Publication 953.2: *Environmental auditor guidelines for conducting environmental audits*

EPA Victoria (2005) Publication 1015: *Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes – Health and Environmental Risk Management*

EPA Victoria (2010) Publication 1304: *Stormwater and Protecting our Waterways*

EPA Victoria (2010) Publication 1333: *Stormwater Management for the Car Repair Industry*

EPA Victoria (2010) Publication 1334: *Stormwater Management for Food Businesses*

EPA Victoria (2009) Publication IWRG632: *Industrial Water Reuse Guidelines*

EPA Victoria (2009) Publication IWRG701: *A guide to the sampling and analysis of water, wastewaters, soils and wastes*

WSAA (2004) *Dual Water Supply Systems, First Edition, Version 1.1, A Supplement to WSA 03–2002,* Water Supply Code of Australia

CFA (2006) Requirements For Water Supplies and Access For Subdivisions In Residential 1 and 2 and Township Zones

CFA, MFB and DSE Fire Services Guidelines – Identification of Street Hydrants for Firefighting Purposes

AS/NZS ISO 19011:2003 *Guidelines for quality and/or environmental management systems auditing*

AS/NZS 4360:2004 *Risk Management*

AS/NZS 3500:2003 *National Plumbing and Drainage Code*

AS 1345 (1995) *Identification of the Contents Of Piping, Conduits and Ducts*

AS 1319 (1994) *Safety Signs for the Occupational Environment*

AS 2845.1 (1998) *Water Supply – Backflow Prevention Devices*

AS 2845.3 (1993) *Water Supply – Backflow Prevention Devices – Field Testing and Maintenance*

AS 2031 (1987) *Sample Collection and Preservation Techniques*

AS 2419.1 (1994) *Fire Hydrant Installations*

Plumbing Industry Commission & Water Authorities (2005) Recycled Water Plumbing Guide

NHMRC Australian Drinking Water Guidelines 2004 (under review 2010)

Department of Sustainability and Environment: Blue-green algae circular 2009/10.

Part 2
Getting WSUD On The Ground

Module 2.1
Starting the project

This module provides information and tools to help Councils evaluate the feasibility of a WSUD project at the concept design stage. Use this resource to gain support and make decisions.

Set the project objectives

One of the first stages in a WSUD project is to define the project objectives. This should capture what the project will achieve. WSUD projects need to consider:

- Water sensitive urban design principles
- Energy and climate impacts
- Social considerations
- Life cycle costs
- Technology selection.

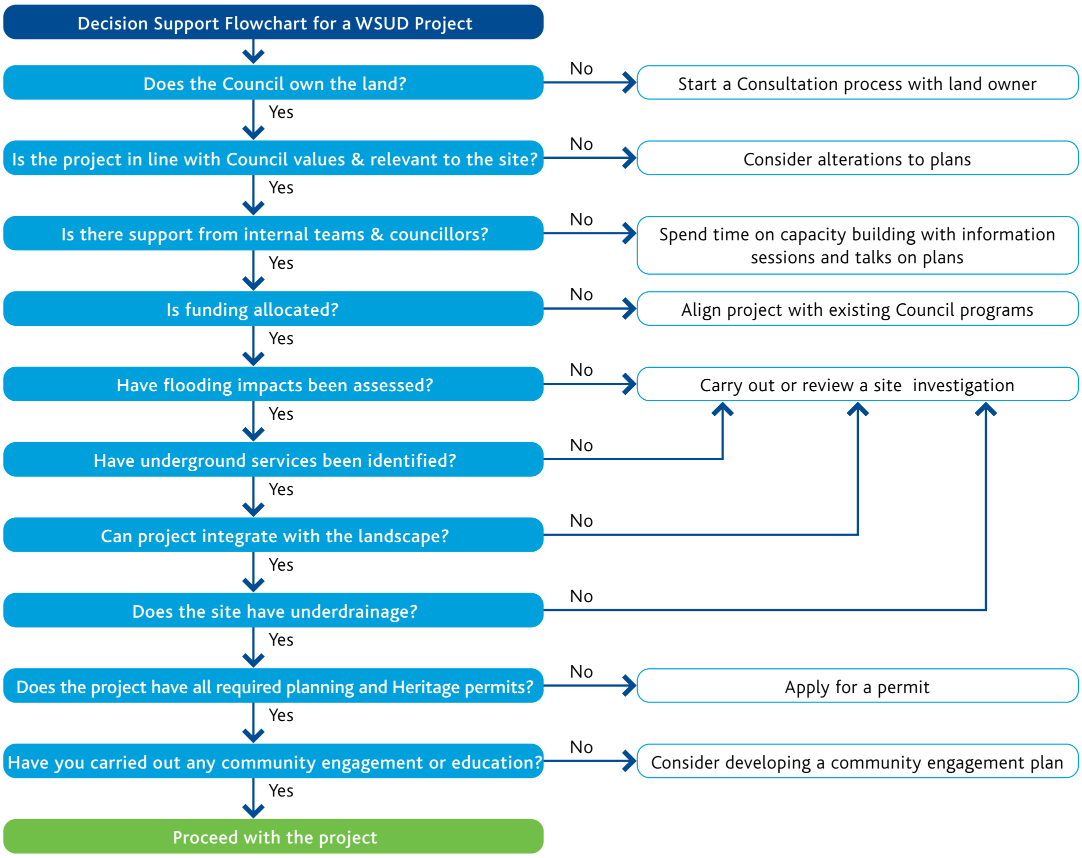
Objectives should as much as possible:

- Reduce potable water demand
- Meet stormwater water quality or flow discharge objectives
- Maintain or enhance landscape amenity and ecosystem value
- Minimise changes to existing topography
- Preserve and maintain the natural drainage system
- Ensure adequate provision for access and maintenance to all services.

To secure internal support, it's important that the objectives of the WSUD project are also in line with the values of the Council.

Decision support tools

Insert any information here about tools that the Council has developed to determine how to evaluate a WSUD project, or decide if should go ahead or not. This will be used to gain support from Councillors and the various teams internally that would be involved.


Decision Support Flowchart for a WSUD Project
Does the Council own the land?
No
Start a Consultation process with land owner
Yes
Is the project in line with Council values & relevant to the site?
No
Consider alterations to plans
Yes
Is there support from internal teams & councillors?
No
Spend time on capacity building with information sessions and talks on plans
Yes
Is funding allocated?
No
Align project with existing Council programs
Yes
Have flooding impacts been assessed?
No
Carry out or review a site investigation
Yes
Have underground services been identified?
No
Yes
Can project integrate with the landscape?
No
Yes
Does the site have underdrainage?
No
Yes
Does the project have all required planning and Heritage permits?
No
Apply for a permit
Yes
Have you carried out any community engagement or education?
No
Consider developing a community engagement plan
Yes
Proceed with the project

Seek funding

Funding sources for WSUD projects can be internal (Council) or external (Federal or State Government)

Internal sources	External sources
Capital works	Melbourne Water stormwater funding
Asset renewal programs	DSE alternative water sources fund
Traffic management programs	Water retailers water saving funding
Parks	Federal funding e.g. Community Water grants

Gain support internally

As WSUD is relatively new, it's important to gain support and capacity building for WSUD projects internally. Hold short information sessions and presentations to colleagues and Councillors. Melbourne Water also provides capacity building support.

Understand the site

Understanding the location of a WSUD project is fundamental to its overall success. Gather a broad overview of the site and identify issues that may assist or delay the overall delivery. At this stage, this can be a desktop study.

For more detail on information to collect, refer to the WSUD Project Checklist.

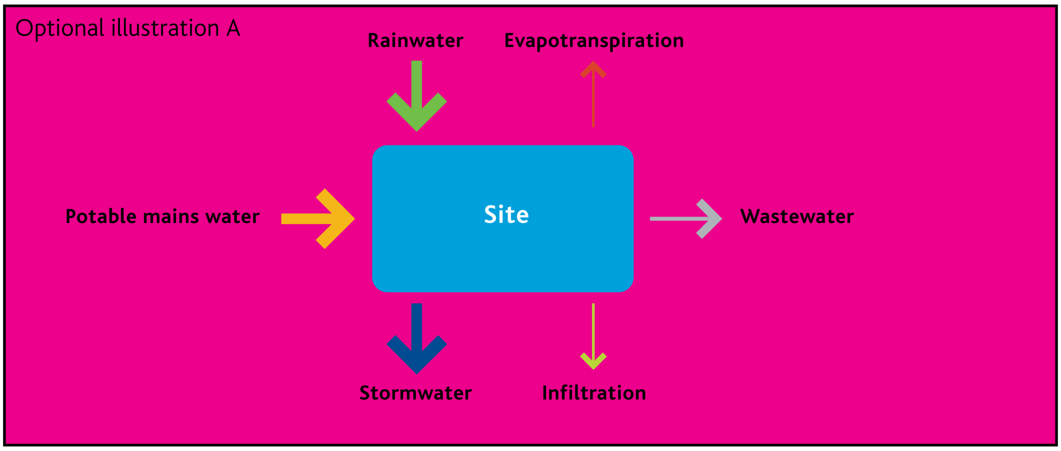
Collect background information

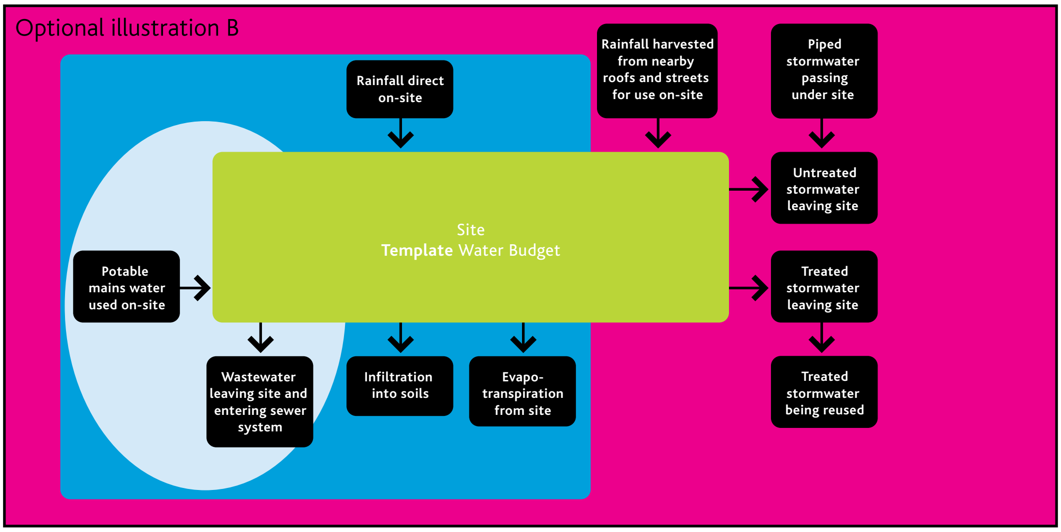
Table 1 Recommended site background information

Data/information to be collected	Source
Land ownership and management	Local plans, land register, land use zonings
Community issues	Complaints to the Council, site visit, known community groups
Terrain information	Aerial photography, contour maps, GIS systems
Catchment boundaries	Catchment planning records
Receiving environment	Catchment or sub-catchment plans
Flooding	Flooding records, EPA
Natural features	Catchment surveys, aerial photography, GIS systems
Heritage listings	Heritage overlays, Heritage Victoria database
Planning constraints	Planning scheme
Strategic catchment planning	Catchment or sub-catchment plans

Conduct a water balance

It's important to understand existing and potential water flows through a site. Construct a water balance which quantifies all water flows in and out of the site to capture this information. This will establish flow data (baseline data) and show how much water is needed for different uses such as toilets and gardens (end-use data).





Carry out a site visit

A site visit is useful for collecting further information and verifying underground services and drainage against GIS information gathered from Council databases.

Involve the community

Involving the community at this stage in a development is important as it helps identify potential issues and can influence the project design. The degree of community consultation will be directed by the scale of the project.

Community concerns could include:

- Visual aesthetics
- Safety
- Use of land
- Flooding concerns
- Ecosystem management.

Through consultation, the ideas, innovations and concerns of a community can be incorporated into the decision making process. Establish open communication early, and a design solution can be developed that has ownership within the community. Community consultation also increases public awareness of water-related issues and can result in positive behaviour change with improved environmental outcomes.

Performance evaluation

The following ready reckoner communication tool is available to help staff and developers with a general understanding of the potential water quality impacts of different WSUD projects.

WSUD Performance Ready Reckoner

To treat 260 sq. metres of road reserve catchment 1 sq. metre of WSUD treatment = 1 small WSUD street tree pit = 26 kgs of TSS removed annually = 1 point	**To treat 780 sq. metres of road reserve catchment** 3 sq. metres of WSUD treatment = 1 large WSUD street tree pit = 78 kgs of TSS removed annually = 3 points	**To treat 2500 sq. metres of road reserve catchment** 10 sq. metres of WSUD treatment = 1 raingarden = 260 kgs of TSS removed annually = 10 points
To treat 1 ha of road reserve catchment 40 metres of WSUD treatment = 1 swale = 1290 kgs of TSS removed annually = 50 points	**To treat 2500 sq. metres of roof** 1.3ML/year of roofwater reused = 100kL rainwater tank = 26 kgs of TSS removed annually = 1 point	**To treat 1000 sq. metres of road reserve catchment** 30 sq. metre of WSUD treatment = porous pavers = 100 kgs of TSS removed annually = 4 points
To treat 5 ha of catchment 1000 sq. metres of WSUD treatment = 1 small wetland = 2600 kgs of TSS removed annually = 100 points	**To treat 5 ha of catchment** 1 small wetland (100 points) + 7 ML/year stormwater reuse = 400 KL storage = 520 kg of TSS removed annually = 20 points In total 120 points	**To treat 5 ha of catchment** Stormwater reuse 7ML/year = 400 KL storage = 2080 kg of TSS removed annually = 80 points

Some new works will be constructed that will generate more stormwater and potentially lower stormwater quality. It's hoped that the number of these projects will reduce over time as awareness of water quality impact grows.

The following 'negative points' can be assigned to works that increase impermeable area.

1,000m^2 pervious open space to 1,000m^2 impervious surface =160 kg/yr TSS = negative 6 points	1,000m^2 pervious open space to 1,000m^2 porous paving =30 kg/yr TSS = negative 1 points

Establish internal systems to easily log pollutant loads and 'point' reductions. Once these are in place, these pollutant reductions can potentially be incorporated into Key Performance Indicators.

Costs of WSUD works

Initial analysis shows the following costs for works. Council staff can then budget the 'points' into their annual capital works planning.

Notes:

- Costs are based on the small number of projects done to date, and will be revised when additional data becomes available
- It's likely that the costs will decrease as works become standard procedure
- Changes in maintenance procedures will also carry a cost.

Model WSUD Project Checklist

Site Details	
Name of project	
Name of officer	
Date	
Address	
Short description of site Treatment technologies to be used Approx. catchment area Size of treatment	
Number and type of WSUD treatments Efficient fittings and appliances? Rainwater harvesting? Stormwater harvesting? Treepits? Raingardens? Swales? Wetlands? Water recycling? Other?	

Part 1: Essential requirements for WSUD project

Action	Issues to consider	Response	Further details
Set project objectives (Module 2.1)	Does the proposal incorporate the following objectives? If not, why not? Consider the objectives below and determine if they are relevant. Also insert any other relevant objectives to the right.		
	Reduce potable water demand?	☐ Yes ☐ No	
	Improve stormwater quality?	☐ Yes ☐ No	
	Maintain or enhance the landscape amenity value?	☐ Yes ☐ No	
	Maintain or enhance local ecology/habitat/biodiversity ?	☐ Yes ☐ No	
	Ensure adequate access and maintenance to all services.	☐ Yes ☐ No	
	Community engagement	☐ Yes ☐ No	
	Briefly, what are the main risks with this project? Public health? Safety? Costs? Carbon intensive? New technology? Other? (Divide into financial, environmental and human health risks)		
Seek funding (Module 2.1)	Internal (Council)		
	Has capital been allocated to the project?	☐ Yes ☐ No	
	If capital has been allocated, how much?		
	Is this project integrated into an existing rolling program for capital works or streetscape works etc?	☐ Yes ☐ No	
	If yes, which program?		
	Have you considered external funding and the timing requirements of these grants? If so, please specify.	☐ Yes ☐ No	
	Have you considered the changes in maintenance procedures, who will maintain the treatment and any likely cost impacts? (Module 2.8)	☐ Yes ☐ No	
Collect background information and carry out a site visit (Module 2.1)	**Land ownership and management**		
	Is land available?		
	Who is it owned by?		
	What are the neighbouring uses of the site? Are there any immediately upstream land uses that are contributing to stormwater pollution and will limit the effectiveness of the proposed WSUD works? Will the WSUD works form part of a treatment train for the downstream catchment?		
	Community issues		
	Are there any community issues that could affect the implementation of the project?		
	Are there any community activities that could benefit or link to the project?		
	Terrain information		
	Are there areas of high or low gradients?	☐ Yes ☐ No	
	Are there flatter areas which may allow larger WSUD measures such as wetlands?	☐ Yes ☐ No	
	Are there level areas which may present difficulties in terms of hydraulic head and high groundwater table?	☐ Yes ☐ No	

Action	Issues to consider	Response	Further details
Collect background information and carry out a site visit (Module 2.1)	**Catchment boundaries**		
	What is the catchment area? Identify the catchment boundaries.		
	Are there any proposed reuse schemes upstream or downstream that will affect, or be affected by, the proposal?		
	Receiving environment		
	Are there any waterways or drainage lines where discharge off site is likely to occur?		
	Flooding		
	Do you have access to information about flooding issues at the site?	☐ Yes ☐ No	
	If so, please specify.		
	Natural features		
	Are there any natural features that need to be assessed?		
	Creek lines?		
	Permanent water bodies?		
	Existing vegetation?		
	Existing infrastructure?	☐ Yes ☐ No	
	If so, please specify.		
	Heritage listing		
	Are there any Heritage considerations you need to take into account?	☐ Yes ☐ No	
	If so, please specify.		
	Planning constraints		
	Are there any planning constraints that would prevent the project going ahead?		
	Environmental corridors?		
	Waterway corridors?		
	Flood lines?		
	Open space or recreational nodes?	☐ Yes ☐ No	
	If so, please specify.		
	Strategic catchment planning		
	Are there any catchment or sub-catchment plans to identify any regional or catchment-scale strategies applicable to the site.	☐ Yes ☐ No	
	If so, please specify.		
	Water balance		
	Do you have enough information on flows to conduct a water balance?	☐ Yes ☐ No	
	Site visit		
	Have you undertaken a site visit?	☐ Yes ☐ No	
	Has an underground service check been carried out?	☐ Yes ☐ No	
	Is there under drainage in the site, with adequate depth? (a depth of approx. 700mm is desirable)	☐ Yes ☐ No	
	Involving the community		
	Have you carried out any form of community engagement or consultation? If so, please specify.	☐ Yes ☐ No	

Part 2: Designing for a WSUD project

Action	Issues to consider	Response	Further details
Integrate WSUD principals into the design (Module 2.2)	**Water conservation**		
	What water saving fittings and devices will be fitted: Tap aerators? Efficient showerheads? Dual flush? High star appliances? Other?		
	What are the water saving targets for the site?		
	Water reuse		
	Will you replace potable water with another water source?	☐ Yes ☐ No	
	If so how?		
	Will you be setting water reuse targets?	☐ Yes ☐ No	
	If yes what are they?		
	Is there potential for rainwater harvesting?	☐ Yes ☐ No	
	Is there potential for stormwater harvesting?	☐ Yes ☐ No	
	Is there potential to reuse greywater?	☐ Yes ☐ No	
	Is there potential to reuse blackwater (water / sewer mining)?	☐ Yes ☐ No	
	Water quality		
	Has a MUSIC Model been carried out for the project?	☐ Yes ☐ No	
	If yes, does the project meet best practice stormwater targets? (80:45:45)		
Assess environmental impacts (Module 2.3)	What are the potential impacts on the aquatic environment from this project?		
	Has a land capability assessment been carried out on the site?	☐ Yes ☐ No	
	What are the potential impacts on the land, primarily from irrigation?		
	What will be the extent of the production of biosolids and other wastes and odours?		
	How will these be managed?		
Assess the climate impacts (Module 2.4)	What are the estimated greenhouse gas emissions that will be generated from the project? (Emissions are from electricity use to run the system and the embodied energy in the materials)		
Assess economic impacts (Module 2.5)	Have you carried out a life cycle costing analysis on the project? If so, please specify.	☐ Yes ☐ No	

Action	Issues to consider	Response	Further details
Assess the risks (Module 2.6)	Have you carried out a risk assessment on the environmental risks on the site?	☐ Yes ☐ No	
	If so, provide details.		
	Have you carried out a risk assessment on the human health risks on the site?	☐ Yes ☐ No	
	If so, provide details.		
	Have you carried out a risk assessment in terms of public safety & access on the site?	☐ Yes ☐ No	
	If so, provide details.		
Design (Module 2.7)	Does the design of the project integrate with existing open space and conservation corridors?	☐ Yes ☐ No	
	Please provide details.		
	Does the design of the project integrate with road layouts and streetscaping?	☐ Yes ☐ No	
	Please provide details.		
	Does the design of the project integrate with lot layouts?	☐ Yes ☐ No	
	Please provide details.		
Operations and maintenance (Module 2.8)	Have you considered operational and maintenance requirements?	☐ Yes ☐ No	
	Have you included annual maintenance costs? If so, please specify.	☐ Yes ☐ No	

Part 3: Beneficial actions for a successful project

Action	Issues to consider	Response	Further details
Relevance of project	Is the project in line with Council contemporary values?	☐ Yes ☐ No	
	Is the project relevant to the site?	☐ Yes ☐ No	
Build internal capacity	Is there support from internal teams and councillors?	☐ Yes ☐ No	
	Have you carried out any awareness sessions with colleagues?	☐ Yes ☐ No	
	Please provide details.		
	Have Councillors been briefed?	☐ Yes ☐ No	
Community engagement	Have you carried out any community engagement or education? Please detail	☐ Yes ☐ No	
	Please provide details.		

Part 2

Module 2.2

Scoping the options

This module takes steps to help develop WSUD options. The steps are:

Step 1: Find ways to reduce water consumption
Step 2: Replace drinking water with an alternative source
Step 3: Treat stormwater before discharge into water bodies.

All three steps are necessary to find the best sustainable water solution using water sensitive urban design. Treating stormwater can be done as the second or third step as any treatment to remove pollutants from stormwater will help to improve the opportunity to reuse that water as an alternative source. Water saving also helps to improve stormwater quality by preventing some runoff (and its pollution) from entering waterways.

Step 1: Find ways to reduce water consumption

Water saving targets

Insert Council water saving targets

Managing the demand for water

Insert information on water usage in the Council area

Until recently, there has been a culture of water being plentiful and cheap in the urban environment. As a result, water has been undervalued and overused. The increasing pressure on our water resources requires a change to this perception. Ideally, our everyday habits must change and our approach and behaviour must reflect the view that potable water is a valuable resource.

Permanent water restrictions such as limiting garden watering, prohibiting hosing hard surfaces, stipulating vehicle washing with buckets and permits for pool filling are now required.

Demand management is a relatively easy way to reduce water consumption. Water demand can be reduced through changing:

- Behaviour
- Regulation
- Technology
- Design.

Demand for water in the home and business can be decreased by installing water efficient:

- Fittings (tap aerators, efficient showerheads, 6/3L dual flush toilets)
- Appliances (5A washing machines and 4A dishwashers).

Larger businesses can improve efficiency in fire sprinkler testing regimes and cooling towers. Food businesses can use waterless woks and more efficient steamers. Businesses with large gardens can use efficient irrigation technology and practices when water restrictions are not in place.

Step 2: Replace drinking water with an alternative source

Water recycling and reuse targets

Insert Council water recycling and reuse targets

Alternative water source hierarchy

Drinking mains water is currently the primary water source for Melbourne. After efforts have been made to reduce demand for water, alternative sources must be considered to decrease the use of drinking mains water.

Using alternative water sources helps to deliver sustainable water outcomes by:

- Saving water (reduced reliance on potable water and the wider water catchment)
- Improving stormwater quality (less stormwater entering the waterways thereby reducing pollution and velocity)
- Reducing wastewater (less wastewater entering the sewer to free up capacity for population growth and to reduce energy and ecological pressures at metropolitan treatment centres).

The urban water cycle has identified a range of potential alternative water sources which can be used depending on the quality of water that is needed (this is known as 'fit-for- purpose' water use). Not all of these options are suitable in all areas due to various environmental, economic and social reasons, and as such the following general hierarchy is recommended.

Alternative Water Sources from within the Local Catchment

1. Consider rainwater harvesting

Smaller rainfall volumes are easy to harvest because the equipment required (such as tanks or storage pond) to hold this volume of runoff can be relatively small, yet able to help meet some of the residential and Council demands on mains water supply. Typically 90% of rainfall volume is attributed to frequent events smaller than the one in three month annual recurrence interval (ARI).

Rainwater harvesting also helps to reduce stormwater pollutants, most particularly nitrogen loads from atmospheric pollutants.

2. Consider stormwater harvesting

Stormwater harvesting allows for a much greater amount of rainwater to be harvested once it has landed on roads, footpaths, open space and other impermeable areas. Stormwater requires treatment therefore it needs more management, financing and energy than rainwater harvesting. Stormwater harvesting generally requires careful planning for large storage areas once the water has been captured and treated.

Stormwater harvesting provides the greatest reductions in stormwater pollutants compared to other alternative water sources. In particular, it reduces total suspended solids (grit, car and tyre residue etc).

3. Consider water recycling

This hierarchy is shaped by a commitment to minimising carbon, and lifecycle implications.

Each water recycling proposal, greywater and blackwater, has unique reliability, energy cost, environmental risk and economic profiles. It is necessary to consider the circumstances of every site to determine the best option for saving water, sourcing alternative water and reducing stormwater pollution.

Alternative Water Sources from beyond the Local Catchment

If the above hierarchy of sustainable water management solutions is not able to meet water conservation and water quality targets, then it is recommended that water sources generated from outside the municipality, but traversing the local region be considered to supplement supply. This includes:

4. Wastewater conveyed along the Melbourne Water Sewerage Transfer Network

Sewer mining is an option for alternative water sourcing on sites that have limited space or other constraints. It does have significant energy implications that need to be managed, but has the benefit of a certainty of supply (unlike rain-dependent options) and much less storage requirements.

5. Stormwater in local waterways

Drawing water from waterways requires full consideration of environmental flow requirements of that waterway. Drawing from upper reaches is not recommended because of the detrimental impacts resulting from reduced environmental flows in waterways.

Whilst the lower reaches do not have the great implications of environmental flows it is often limited by the water in these lower reaches being saline and requiring significant treatment and desalination.

6. Groundwater

Groundwater is a highly variable resource across Melbourne and localised circumstances need to be researched. The lower Yarra region does not provide a significant groundwater resource because of the shallow, saline water table across the Yarra Delta region[4]. If extracted, groundwater often needs to be desalinated.

Central Melbourne is located on unconsolidated quaternary alluvium deposits and therefore it is characterized by a very low storage potential for aquifer storage recharge.

Water quality considerations

Water quality and typical treatment required for urban water sources and the associated impacts on climate change and risks to human health are summarised in Table 1. Reused water (greywater and blackwater) has minimal risks if appropriately treated and used as discussed in Module 2.6.

Table 1. Summary of water quality for urban water streams

Water	Source	Quality	Treatment required	Use
Drinking mains water	Reticulated (piped) water distribution	High quality	None	General domestic uses
Roof runoff	Rainwater from roof	Reasonable quality	Low level – typically sedimentation occurs within a rainwater tank	Toilet flushing, garden irrigation, washing machine, hot water system
Stormwater runoff	Catchment runoff (includes impervious areas such as roads, pavements, etc)	Moderate quality	Reasonable treatment to remove litter and reduce sediment and nutrient loading	Toilet flushing, garden irrigation, washing machine, hot water system
Greywater	Shower, bath, bathroom basins, washing machine	Wastewater – variable organic loading and pathogens	Moderate to high treatment level required to reduce pathogens and organic content No treatment required if used within 24 hours and subsurface irrigation	Toilet flushing, garden irrigation, washing machine
Blackwater	Kitchen, toilet and bidet water from the sewer	Wastewater. Lowest quality – high levels of pathogens and organics	Advanced treatment and disinfection required	Toilet flushing, garden irrigation

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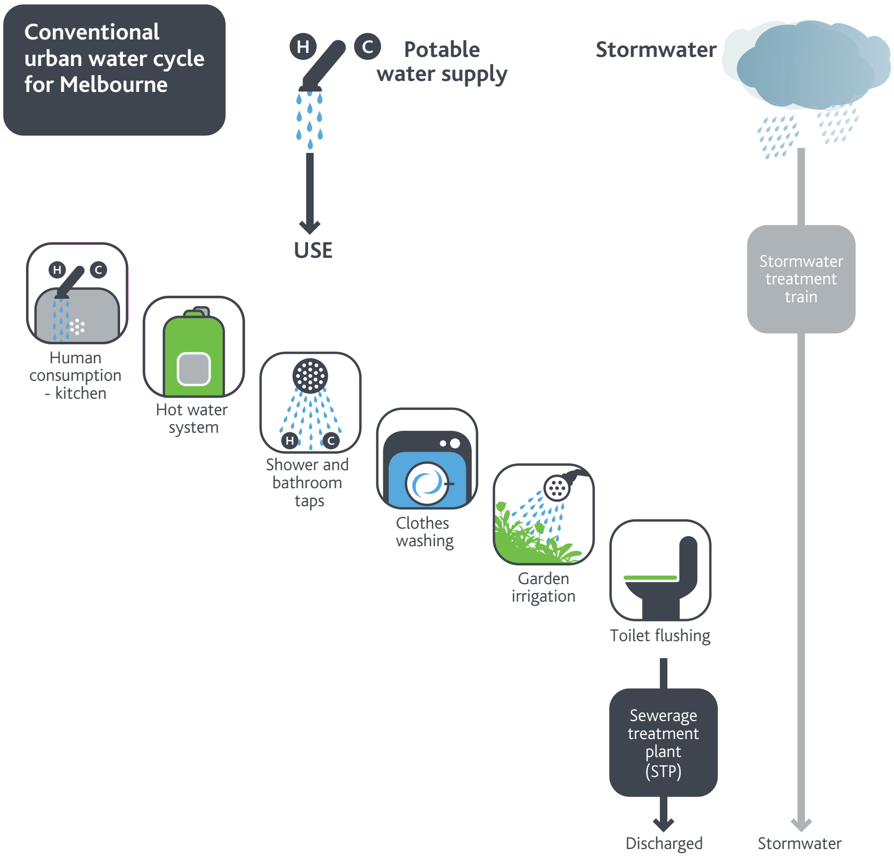
[4] Broad scale potential mapping exercise undertaken by Dudding et al (2006).

Conventional urban water cycle

Melbourne's conventional urban water cycle has a 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 sewage treatment plants. The treated water is then discarded to Port Phillip Bay and Bass Strait. Stormwater is discharged to the bay via drainage pipes and the Yarra River.

Figure 5. Conventional urban water cycle for Melbourne



Rainwater harvesting

Rainwater covers water that is captured on roofs. It is an alternative water source for use within the City, as shown in Figure 6.

Rainwater can be used for:

- Toilet flushing
- Garden irrigation
- Washing machines
- Hot water systems.

Water storage tanks can be strategically incorporated into new or existing buildings and open space areas without impacting on the aesthetics of the building or streetscape. Tanks should be appropriately sized to maximise their reliability and usefulness. Details of tank sizing, installations and approvals can be found in the *Rainwater Tank Fact Sheets 2, 3 and 8*.

The capture and use of rainwater is an environmentally preferable option for sourcing alternative water supplies. Rainwater captured from a roof has a low level of pollution and this means that treatment is not always necessary. Because the water is reused on the same site, materials are minimised and less energy is needed to pump the water to its intended use. This reduces resource consumption and lowers greenhouse gas emissions.

The amount of pollutants entering the waterways is also reduced. Rainwater harvesting will primarily reduce the total nitrogen load, which has been picked up as airborne pollutants. A reduction in nitrogen means less algae and plant growth. This growth in waterways can inhibit invertebrate and fish diversity. A reduction in runoff to streams is another benefit for urban stream health and flood mitigation.

Stormwater harvesting

Stormwater harvesting provides an alternative water source that can be captured from roads, footpaths, car parks, open space and gardens for use within the City as shown in Figure 6.

Stormwater can be used for:
- Toilet flushing
- Garden irrigation
- Washing machines
- Hot water systems.

Water storage tanks are used for stormwater as well as rainwater harvesting. They 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 appropriately sized to maximise their reliability and usefulness. Details of tank sizing, installations and approvals can be found in the *Rainwater Tank Fact Sheets 2, 3 and 8*.

Stormwater can also be stored at ground level including ponds and waterbodies in open space areas.

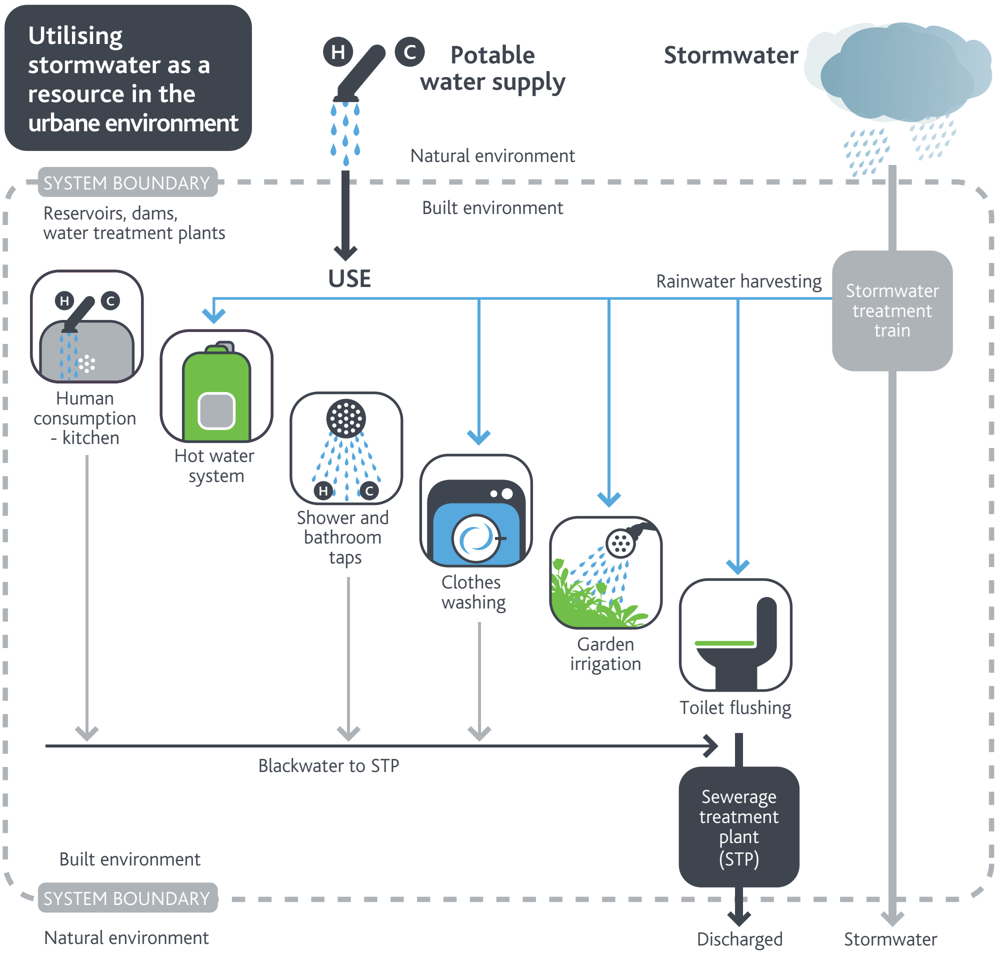
The onsite capture and use of stormwater requires more treatment than rainwater harvesting, but less treatment than many water recycling options. Capturing stormwater also helps to reduce the amount of pollutants entering the waterways. If stormwater is captured from:
- Roads and carparks, it will primarily reduce the total suspended solid load, which includes the general grit and tyre/car residue
- Garden areas, it will primarily reduce the total nitrogen and total phosphorus loads from fertilisers.

Reducing these pollutants will help fish, invertebrates and macrophytes stay healthier.

Stormwater reuse will also aid in flood mitigation and urban stream health by reducing runoff .

Stormwater treatment is further described in Step 3: Managing stormwater before discharge into the environment

Figure 6. Utilising stormwater and rainwater as a resource in the urban environment



Greywater reuse

Greywater can save significant quantities of drinking water and reduce the amount of wastewater going to a sewerage treatment plant. It can require treatment, or can simply be diverted untreated.

Greywater varies in quality depending on the amount of organic loading it has in it, which is determined by its original use:

- Residential and commercial greywater includes water from the laundry, bathroom taps and shower
- Industrial greywater includes slightly polluted water reused in manufacturing.

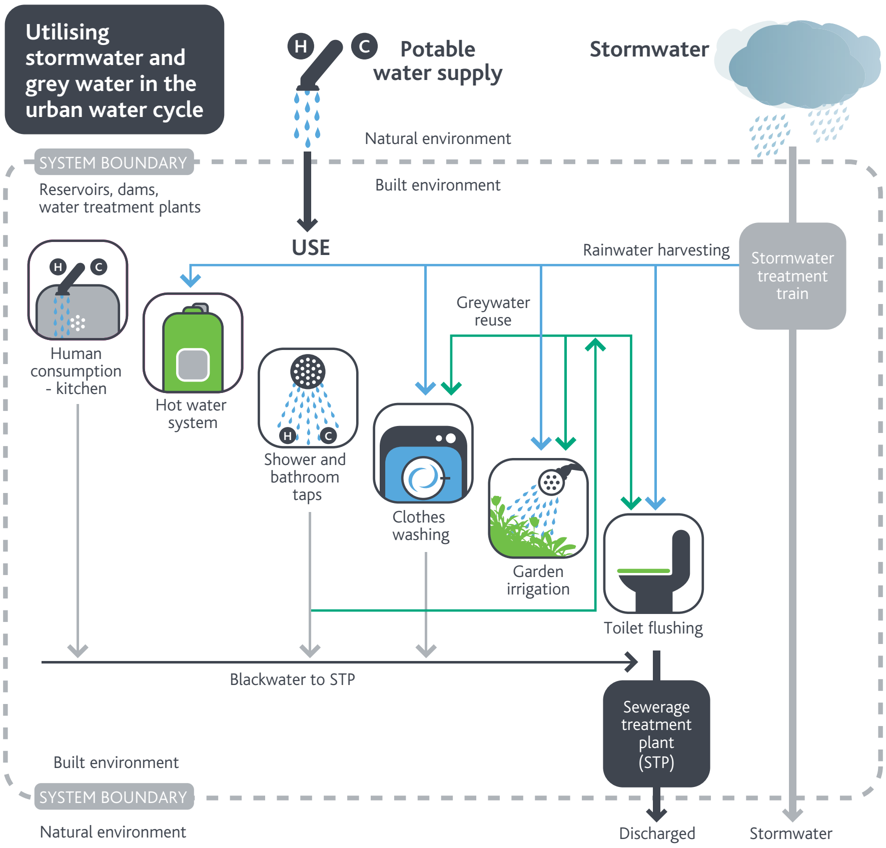
Greywater may need treatment as it contains contaminants made up of low levels of bacteria, faecal matter, organic matter, micro-organisms, salts and detergents. These are dangerous to human health and can degrade water colour and create odours.

The level of 'treatment' of greywater depends on its end use and exposure pathway (the extent to which humans will come into contact with it). Options include:

- Simple screening of pollutants using a mesh
- Settlement in a tank
- Chemical treatment
- Biological treatment.

Figure 7 shows how stormwater and greywater can be reused.

Figure 7. Utilising stormwater and grey water in the urban water cycle

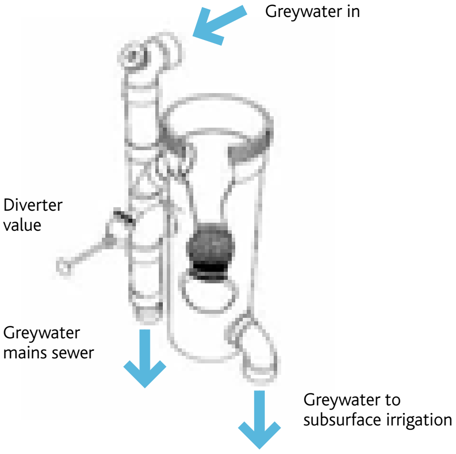


Small-scale greywater diversion

A simple greywater reuse system diverts greywater to the garden for irrigation. This means greywater can be used straight away, with little treatment and minimal human contact.

Figure 8 shows a typical system where greywater is redirected to the garden through a subsurface irrigation system using a diverter valve. The system can be retrofitted to existing buildings close to washing machines or sinks. Care must be taken to reduce the clogging and blockages of dispersion systems.

Figure 8. Greywater diverter (www.greywatersaver.com)



Managing risks associated with greywater

Human exposure to greywater should be limited. A closed system is best for collection, treatment and reuse. At the simplest level, the following principles should be followed to manage health risks[5]:

- Don't make cross connections between greywater and drinking water systems
- Direct excess greywater to the sewer
- Use a self-contained system
- Limit exposure to the greywater system
- Don't use greywater during wet weather
- Don't use greywater to irrigate vegetable gardens.

With simple greywater systems, there is no provision for storage in the system. Irrigation is subsurface, so human exposure is limited. In this situation, there is no direct contact between greywater and people, and public health risk is extremely small.

Currently there is no Victorian legislation specific to the use of untreated greywater. Simple greywater diversion systems do not require EPA or Council approval[6]. All plumbing should be completed by a licensed plumber in accordance to Australian Standards *(AS3500.1.2 Water Supply: Acceptable Solutions)*. Further advice is available from EPA Victoria and the Victorian Department of Human Services.

Temporary greywater storage

Greywater can be temporarily stored in an underground tank, to be reused at a later time. Garden irrigation is an appropriate use for this type of system. The Department of Human Services does not recommend the use of untreated greywater within the household[7]. Storing untreated greywater is hazardous, as it may lead to microbial growth and therefore produce odours and septic water. Greywater can be stored for up to 24 hours without treatment before it must be discarded to sewer. If greywater is to be stored for more than 24 hours it must be treated and disinfected.

Greywater treatment

Greywater from the shower, bath and basin in bathrooms requires treatment before it is reused. If it is to be used again, additional infrastructure is needed to install a reuse system, including underground tanks, pumps and an onsite disposal system. Figure 6 shows an overview of a greywater system.

Figure 9. Schematic of greywater reuse system

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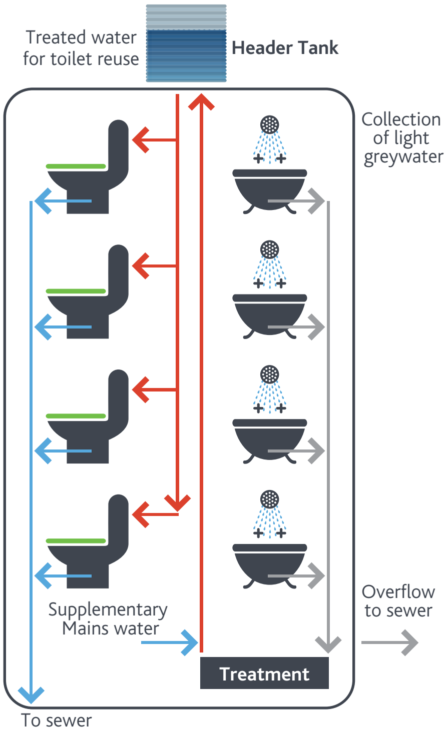
[5] NSW Health (2000) *Greywater reuse in sewered single domestic premises.*
[6] Refer Victoria EPA (2001) Reuse options for household wastewater – publication 812.
[7] Department of Human Services (2003) Appropriate reuse of greywater.

For a multi-storey residential development, a dedicated collection system is needed to collect the greywater and a separate system for treated water reuse (Figure 10). A header tank is typically installed to minimise fluctuations during the day.

Figure 10. Greywater system within a multi-storey residential development



Meeting water quality standards for greywater

Greywater systems that involve treatment are considered to provide a permanent supply and attract more stringent conditions than direct diversion of untreated greywater. These systems must use an EPA approved treatment system, require a council permit, and must be operated and maintained in accordance with relevant permits and authorities.

For greywater systems treating less than 5,000 litres per day, a more simplified quality standard has been adopted by the EPA, compared with that used for larger scale systems that may also treat sewage/blackwater for recycling. These standards are:

20/30 standard:
Water quality standard indicating an effluent quality of <20 mg/L BOD5 and <30 mg/L suspended solids.

20/30/10 standard:
Water quality standard indicating an effluent quality of <20 mg/L BOD5, <30 mg/L suspended solids and *E.coli* <10 cfu/100 mL.

10/10/10 standard:
Water quality standard indicating an effluent quality of <10 mg/L BOD5, <10 mg/L suspended solids and *E.coli* <10 cfu/100 mL.

Greywater treated to these standards can be used for the following applications:

Table 2. Approved uses of treated greywater[a] (EPA Victoria, Publication 891.2, Table 5.1)

Treatment	Appropriate use of greywater sourced from and recycled on single domestic premises		Appropriate use of greywater sourced from and recycled on multi-dwelling[b]/ commercial[c] premises	
Secondary treatment (20/30 standard) (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yes[d]
	Surface irrigation	No	Surface irrigation	No
	Toilet flushing	No	Toilet flushing	No
	Washing machine	No	Washing machine	No
Secondary treatment and disinfection (20/30/10 standard) (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yes[d]
	Surface irrigation	Yes	Surface irrigation	Drip only[d]
	Toilet flushing	No	Toilet flushing	No
	Washing machine	No	Washing machine	No
Advanced secondary treatment and disinfection (10/10/10 standard)[g] (≤5000L/day)	Subsurface irrigation	Yes	Subsurface irrigation	Yesd
	Surface irrigation	Yes	Surface irrigation	Drip only[d]
	Toilet flushing	Yes	Toilet flushing	AGWR standard only[f]
	Washing machine	Yes[e]	Washing machine	AGWR standard only[f]

a. This table only refers to recycling greywater that has been treated in an EPA-approved greywater treatment system. Greywater may not be recycled for any purposes other than those outlined in this table. Treated greywater must not come in contact with the edible parts of herbs, fruit or vegetables. Greywater may contain contaminants originating from products such as bleach, paint and dye. Greywater potentially containing such contaminants may not be sufficiently treated in a greywater treatment system and should therefore be discharged to sewer (in sewered areas). In unsewered areas, the use of these products should be avoided altogether. When greywater is sourced from the laundry and recycled via garden irrigation, liquid detergents should be used, as powder detergents contain a high amount of salt which may be detrimental to plant and soil health.

b. Multi-dwelling premises: one site with numerous buildings, some or all of which are connected to one common onsite greywater treatment system.

c. Commercial premises: see section 1.2.

d. Sites with sensitive subpopulations such as hospitals, aged care facilities, childcare centres and schools should only use sub-surface irrigation, and not irrigate children's play areas (such as lawns).

e. It should be noted that greywater recycling for clothes washing may not always result in the desired outcome, especially when washing light-coloured clothes.

f. Recycling greywater for internal use at multi-dwelling and commercial premises is not recommended unless the system that has demonstrated compliance with the Australian Guidelines for Water Recycling (AGWR), including the ongoing operation and management.

g. Note that 10/10/10 standard is not 'Class A' standard. 'Class A' standard is only applicable for larger systems that treat more than 5000 litres of wastewater per day (refer to EPA Publications 464.2, Use of Reclaimed Water and 1015, Dual pipe water recycling schemes – health and environmental risk management).

Larger-scale greywater treatment technologies

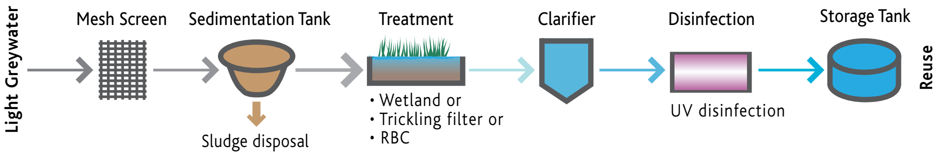
Typically, a greywater treatment system is a combination of treatment technologies that are sequentially placed to form a treatment train. Figure 8 illustrates the key components of a generic treatment train.

A treatment train should provide a graduated level of treatment from primary through to tertiary (advanced) treatment. Using only one measure will not adequately address the range of pollutants generated in a typical urban development. Therefore a series of individual treatment measures must be developed.

The treatment train should consider the optimal operating environment for each treatment measure, taking into account:

- Contributing catchment area
- Hydraulic and pollutant loading
- Treatment process employed
- Soil type and ground water
- Maintenance and public health issues.

Figure 11. Typical treatment train for a greywater reuse system



Mesh screen: The mesh screen physically traps and removes larger objects from the greywater reuse process.

Sedimentation tank: The sedimentation tank works as a surge tank to regulate inflow into the treatment system. The tank helps remove larger-sized pollutants through sedimentation (the natural settlement of solids).

Treatment: Treatment of greywater from a wetland through trickling filter or rotating biological contactor (RBC) reduces and/or dissolves organic matter.

Clarifier: The clarifier acts to stabilise flow and removes excess biomass by sedimentation.

Filtration (not shown): Filtration happens through either sand or a membrane to improve the level of the water quality. This is dependent on relevant health regulations.

Disinfection: If organic material is not removed, greywater may become anaerobic and give off odours. Disinfection kills micro-organisms including pathogens and bacteria to minimise public health risks and prevent biofouling in the system. Ultraviolet (UV) disinfection is preferable, although this can also be achieved by chlorination and ozonation (refer to Fact Sheet 22). DHS will often prefer an element of residual disinfection achieved only by chlorination.

Technologies available for large greywater systems

There are a range of technologies available for treatment of larger greywater reuse systems. These include:

- Subsurface flow wetlands *(Fact Sheet 16)*
- Suspended growth systems e.g. activated sludge systems *(Fact Sheet 17)*
- Fixed growth systems e.g. trickle filters, rotating biological contactors (RBC) *(Fact Sheet 18)*
- Recirculating media filters (fixed film bioreactor) *(Fact Sheet 19)*
- Sand and depth filtration *(Fact Sheet 20)*
- Membrane filtration (micro, ultra, nano filtration and reverse osmosis) *(Fact Sheet 21)*
- Membrane bioreactor *(Fact Sheet 17)*.

This technology list is only a guide and not exhaustive. It aims to capture the most common and applicable treatment systems available. Technology selection depends on a range of criteria including:

- Water use
- Water quality and quantity
- Available space
- Economic considerations
- Other environmental objectives, e.g. greenhouse gas emissions and land capability
- Climatic conditions
- Operating and maintenance.

Each treatment and technology should be evaluated on a case-by-case basis. An overview of pollutant removal is presented in Table 3, with more detailed information provided in the relevant Fact Sheets.

Table 3. Overview of treatment technologies and their pollutant removal abilities[8]

	Suspended solids (TSS)	Biodegradable organics (BOD removal)	Nutrients-nitrogen	Nutrients-phosphorous[9]	Salts	Pathogens
Subsurface flow wetland *(Fact Sheet 16)*	Yes	Yes	Yes	Yes	No	Good[10]
Biological processes – suspended growth systems *(Fact Sheet 17)*	Yes	Yes	Yes	Limited	No	Limited
Biological processes – fixed growth *(Fact Sheet 18)*	Yes	Yes	Yes	Limited	No	Limited
Recirculating media filter *(Fact Sheet 19)*	Yes	Yes	Yes	Limited	No	Limited
Depth Media Filtration *(Fact Sheet 20)*	Yes	Function of size	Limited	Limited	No	Limited
Membrane filtration *(Fact Sheet 21)*[11]	Yes	Function of size	Function of size	Function of size	Reverse osmosis only	Function of size
Disinfection *(Fact Sheet 22)*	No	No	No	No	No	Yes

As shown in Table 4, the scale of the site will influence which technology is selected:

- For single households, simple greywater reuse systems are preferable
- Larger systems are more appropriate for larger scale applications with associated management and maintenance.

Table 4. Suggested 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

Blackwater reuse

Melbourne has an extensive city sewerage network that is presently designed to transport wastewater to large-scale treatment plants. This water could be used as a resource. The wastewater (blackwater) can be extracted from the sewerage system, treated and reused appropriately for irrigation purposes or for toilet flushing.

Blackwater reuse (or 'water mining') requires a higher level of treatment than greywater. The treatment train must include disinfection to reduce high pathogen levels.

Treatment can be energy intensive. When selecting a blackwater project, the broader ecologically sustainable development objectives must be considered, particularly the greenhouse gas emissions and a land capability assessment (LCA).

An LCA assesses the capability of the site to sustainably manage wastewater and looks at parameters such as the site drainage, rainfall and soil characteristics. For more information on LCAs, EPA Victoria has an information bulletin *Land capability assessment for onsite domestic wastewater management*, Publication 746.1.

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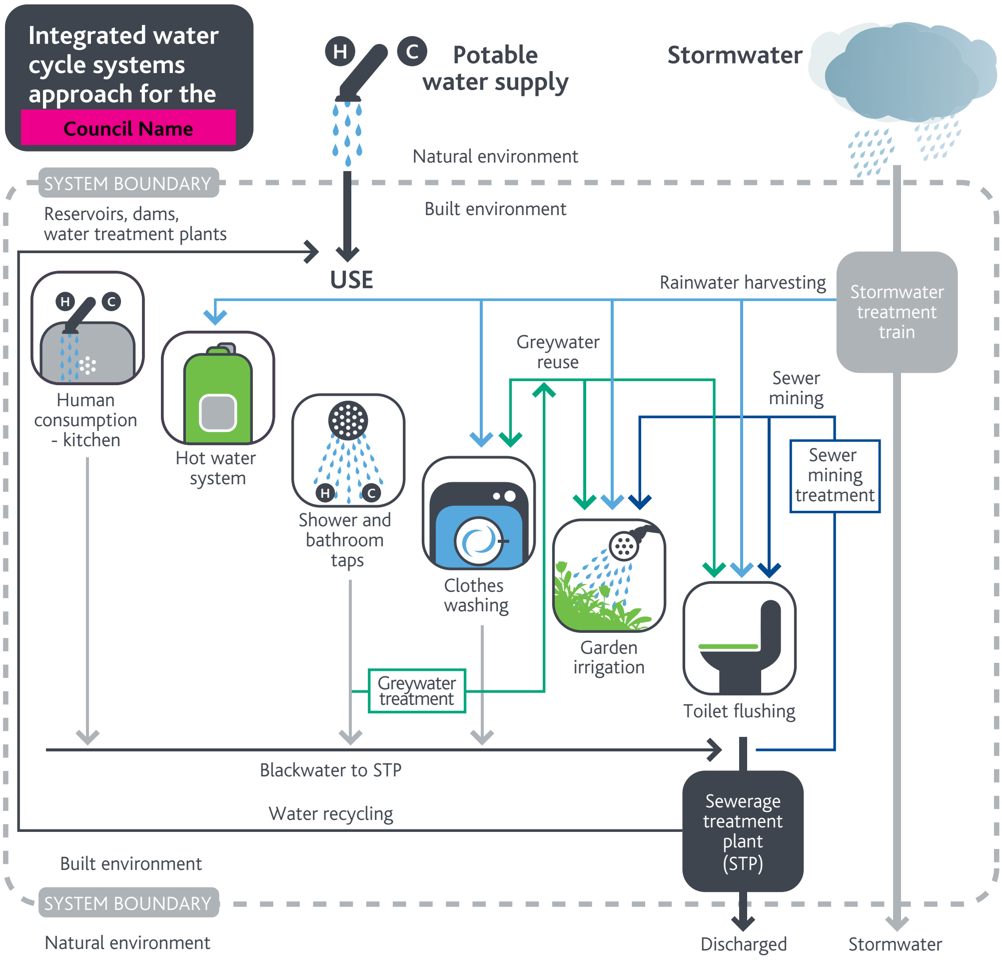
[8] Refer to Crites and Tchobanoglous (1998) Small and decentralised wastewater management systems, McGraw-Hill.
[9] Phosphorous removal is dependent on the reactor configuration and the scale of treatment system.
[10] Further pathogen removal, such as disinfection may be required to meet EPA Victoria requirements.
[11] Pollutant removal by membrane filtration is a physical separation process with pollutant removal dependent on the pore size, refer to Fact Sheet 21.

Figure 12. Integrated water cycle systems approach



Water mining (Sewer mining)

Water mining (also referred to as 'sewer mining') involves:

- Extracting wastewater from the sewerage (blackwater) system
- Treating and recycling the water
- Disposing of the remaining waste to the sewer for centralised treatment.

Water mining systems are typically a combination of technologies and can be purchased as 'package treatment plants'. These are compact, sometimes portable treatment stations available from proprietary companies. Often they are sized to fit inside a shipping container.

Sewer flow rates and quality

Effective water mining matches water demand with blackwater supply. The flow of a sewer changes with people's behaviour. Flows peak in the morning and evening. As the sewerage system becomes larger, so does the sewer catchment, so there is less variation in peak flows. The supply of water increases with a greater source and upstream network.

When a collection system is smaller, it's more sensitive to variations in flow. This limits the potential for continuous sewer extraction, and an onsite surge tank may be needed to meet periods of high demand.

The exact design of the surge tank will depend on the collection system and the sewer extraction point. A smaller upstream collection network means varying blackwater quality. Avoid potentially hazardous consumers such as industrial and other trade waste customers by carefully selecting sewer extraction points.

Water quality

Blackwater extraction from sewers is highly contaminated and of variable water quality.
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, including: pathogenic bacteria, viruses, protozoa and helminths
- High nutrients - total nitrogen (20-705 mg/L) and total phosphorous (4 -12 mg/L)[12].

As with greywater, the level of 'treatment' of greywater depends on its end use and exposure pathway. Usually, water used for toilet flushing and uncontrolled public access irrigation must be high quality. EPA Victoria's guidelines for Dual Pipe Water Recycling Schemes (Publication 1015) and, use of reclaimed water (publication 464.2) specify the quality of recycled water needed for a particular end use.

These are quality standards and uses are summarised as:

Table 5.

Class	Water quality objectives – medians unless specified	Range of uses – uses include all lower class uses
A	Tertiary treatment with disinfection Bacteria[a]: < 10 *E.coli*/100 mL Viruses[b]: 7-log reduction[c] from raw sewage to recycled water Protozoa[b]: 6-log reduction[d] from raw sewage to recycled water	Urban (non-potable): with uncontrolled public access Agricultural: eg human food crops consumed raw Industrial: open systems with worker exposure potential
B	Secondary treatment and pathogen (including helminth reduction for cattle grazing) reduction[f] · <100 *E.coli* org/100 mL · pH 6 – 9[e] · < 20 / 30 mg/L BOD / SS[g]	Agricultural: eg dairy cattle grazing Industrial: eg washdown water
C	Secondary treatment and pathogen reduction[g] (including helminth reduction for cattle grazing use schemes) · <1000 *E.coli* org/100 mL · pH 6 – 9[e] · < 20 / 30 mg/L BOD / SS[g]	Urban (non-potable) with controlled public access Agricultural: eg human food crops cooked/processed, grazing/fodder for livestock Industrial: systems with no potential worker exposure
D	Secondary Treatment · <10000 *E.coli* org/100 mL · pH 6 – 9[e] · < 20 / 30 mg/L BOD / SS[g]	Agricultural: non-food crops including instant turf, woodlots, flowers

a. Median – to be demonstrated during treatment plant validation.

b. As a default, the most resistant (or worst-case) virus or protozoan should be used at each treatment step for calculating log reductions. However, suppliers have the option of undertaking the more complex approach of assessing treatment processes based on the removals provided across the system for key pathogenic organisms (rotavirus, adenovirus, Hepatitis A virus, Cryptosporidium oocysts, Giardia cysts).

c. Median removal, with a lower (critical) limit of 6-log reduction.

d. Median, with a lower (critical) limit of 5-log reduction.

e. pH range is 90th percentile. A higher upper pH limit for lagoon-based systems with algal growth may be appropriate, provided it will not be detrimental to receiving soils and disinfection efficacy is maintained.

f. Guidance on pathogen reduction measures and required pre-treatment levels for individual disinfection processes are described in GEM: Disinfection of Reclaimed Water (EPA Victoria, 2003 Publication 730.1). Helminth reduction is either detention in a pondage system for greater than or equal to 30 days, or by an NRE and EPA Victoria approved disinfection system (for example, sand or membrane filtration).

g. Where Class C or D is via treatment lagoons, although design limits of 20 milligrams per litre BOD and 30 milligrams per litre SS apply, only BOD is used for ongoing confirmation of plant performance. A correlation between process performance and BOD / filtered BOD should be established and in the event of an algal bloom, the filtered BOD should be less than 20 milligrams per litre. a Where schemes pose a significant risk of direct off-site movement of reclaimed water, nutrient reductions to nominally five milligrams per litre total nitrogen and 0.5 milligrams per litre total phosphorous will be required.

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[12] Metcalf and Eddy (2003) *Wastewater Engineering – Treatment and Reuse, Fourth Edition*, McGraw-Hill, p.191.

Figure 13. Schematic overview of a sewer mining

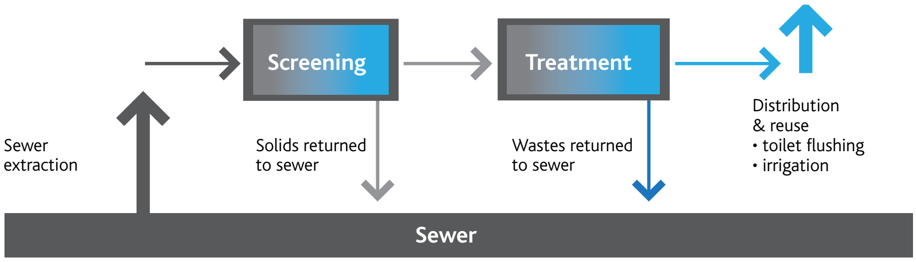


Figure 13 shows a typical water mining treatment systems, consisting of:

- Water extraction from the sewer
- Screening and treatment before reuse.

Extraction

Minimise solids extraction, and therefore treatment costs, through:

- Using a pumping system that transports blackwater from the sewer to the treatment system
- Positioning the extraction point closest to the surface within the sewer.

Screening and treatment

After extraction, a primary separation process commonly takes place to remove any remaining solids. Screening is the most common physical separation process used, and the screened solids are immediately returned to the sewer. Wastewater can be used to continually clean the screen, and preventing clogging. Alternatives to using screens before pre-treatment include:

- Hydro-cyclone separators
- Sedimentation
- Enhanced sedimentation
- Dissolved air flotation (DAF) devices.

All of these techniques separate solid matter from wastewater.

After treatment, most systems need disinfection to control the high pathogen concentrations. Disinfection methods are explored in *Fact Sheet 21*.

Water mining technologies

Water mining technologies are similar to those used for greywater systems. The main difference is in inflow wastewater quality. Water mining treatment must:

- Reduce the high organic and micro-organism concentrations
- Control pathogen levels.

The technology is designed to accommodate changes in water characteristics and pollutant loading. A range of treatment technologies can be used for water mining, including:

- Subsurface flow wetlands *(Fact Sheet 16)*
- Suspended growth systems, e.g. activated sludge systems *(Fact Sheet 17)*
- Fixed growth systems, e.g. trickle filters *(Fact Sheet 18)*
- Recirculating media filters (fixed film bioreactor) *(Fact Sheet 19)*
- Sand and depth filtration *(Fact Sheet 20)*
- Membrane filtration (micro, ultra, nano filtration and reverse osmosis) *(Fact Sheet 21)*
- Membrane bioreactor *(Fact Sheet 17)*.

The technologies listed above include both:

- Commercially available technologies
- New technologies expected to become commercially viable as competition increases in the water market.

Selecting a technology should be done on a case-by-case basis, with key considerations similar to greywater treatment. Importantly, the water use will determine required water quality, as recommended by EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* (publication 464.2).

Table 6 shows how the scale of the site will influence the treatment technology. For single households, greywater reuse is preferable to blackwater treatment. Blackwater treatment and reuse is more appropriate for larger scale applications.

Table 6. Suggested blackwater treatment technology for different scales

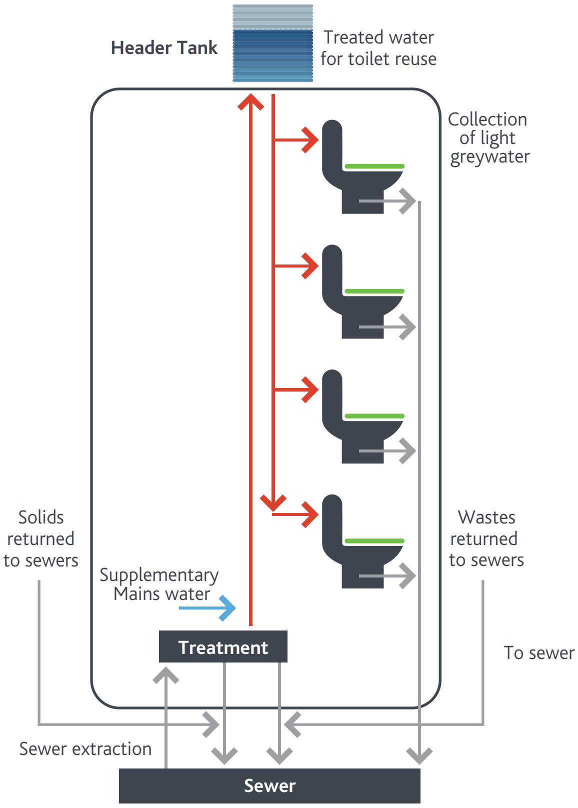
Scale	Treatment technologies
Small Household	Should be sent to centralised sewerage treatment plant (STP) via sewer. Onsite treatment biological treatment systems are available
Medium High rise residential development Mixed use urban development Residential urban development/redevelopment	Biological processes – suspended growth systems Biological processes – fixed growth systems Recirculating media filter Depth filtration Membrane filtration Disinfection
Large Commercial development Industrial development	Biological processes – suspended growth systems Biological processes – fixed growth systems Depth filtration Membrane filtration Disinfection

Recycled water use in buildings

Commercial high-rise developments offer opportunities for water mining, where other potential water sources such as rainwater harvesting are limited due to the size of the roof catchment. In a similar way, greywater production in commercial buildings is limited by lack of showers. Therefore the sewer provides a consistent water resource and water mining is the most appropriate treatment technology.

Toilet flushing is the main water consumer in commercial buildings. High quality drinking water is unnecessary for toilet flushing and treated blackwater is perfectly adequate. Consequently, water mining provides a good match between appropriate use and supply. Figure 14 shows a typical water mining plumbing schematic for a high-rise commercial development.

Figure 14. Typical plumbing requirements for sewer mining within high rise development



Water mining systems need a dedicated dual supply pipe to deliver the reclaimed water to toilets, cold washing machine tap and/or irrigation. Adequate provision of the pipe network is essential during the building's construction. Treatment technologies can be located in the basement of the building through 'package plants'.

Step 3: Treat stormwater before discharge into waterways

This section includes a methodology for setting stormwater quality targets.

Why is it useful to have a stormwater quality target?

The WSUD Guidelines are designed to encourage all projects to be measured, and their contribution to improving water quality logged as progress in meeting a water quality improvement target for that municipality. This will help in understanding the water quality impact of each WSUD initiative.

Melbourne Water has worked with Council Name to establish a simple stormwater target framework based on rigorous analysis of land use, rainfall and pollutant loads. Such a target is needed to meet the regulatory requirements of State Environment Protection Policy (Waters of Victoria).

Previously, Councils have been able to measure litter reduction progress through litter counts on the streets, in waterways and in litter traps.

Progress in understanding and implementing water sensitive urban design solutions is helping to move stormwater treatment closer to the source. That is, pollutants can be prevented from reaching the stormwater system in the first place and there is less reliance on catching the pollutants in the drains just before entering the waterways. This has the benefit of reducing maintenance on litter traps, and also increases capture of finer pollutants such as:

- Total suspended solids (grit, tyre and car residue)
- Nitrogen (airborne pollutants and fertilisers)
- Phosphorus (fertilisers and detergents).

Melbourne Water is providing support to all municipal councils to undertake municipal target setting.

What stormwater targets should each Council have?

Over the past few years, the stormwater industry has increasingly been encouraging and regulating for each development site to treat stormwater. These efforts aim to achieve:

- 80% reduction in total suspended solids (grit, tyre and car residues etc)
- 45% reduction in total phosphorus (fertiliser, detergent)
- 45% reduction in total nitrogen (airborne pollutants, fertiliser)
- 70% reduction in litter.

Council may set stormwater targets by choosing to use a single ‘indicator’ pollutant to report against. Total suspended solids is considered the appropriate indicator pollutant for built up inner areas.

Stormwater Target Setting: Council Name

Insert Council water recycling and reuse targets

Stormwater treatment measures

Best practice urban stormwater management aims to meet multiple objectives including:

- Providing flood conveyance to reduce flow volumes and velocities (safe transport of floodwaters downstream that reduces risk to humans, riverine habitat and infrastructure)
- Removing contaminants to protect downstream aquatic ecosystems.
- Providing for infiltration to groundwater and baseflow
- Promoting WSUD elements as part of the urban form.

Infrastructure to avoid nuisance flooding and flood damage to public and private property is a fundamental requirement of a stormwater system. At the same time, a stormwater system should also provide on-site stormwater retention and detention. This protects downstream aquatic ecosystems from increased flow volumes and rates associated with urbanisation.

Typical urbanisation produces many contaminants that can be blown or washed into waterways and affect the health of streams and waterways. Best practice stormwater management makes sure that runoff is treated to remove water borne contaminants and protect or enhance the environmental, social and economic values of receiving waterways.

Stormwater can carry a wide range of pollutant types and sizes. No single treatment measure can effectively treat all pollutants carried by stormwater. A combination of treatments is therefore required to reduce the range of pollutants contained in stormwater.

Table 7. Site conditions and benefits of stormwater treatments

Treatment Measure	Potential benefits	Suitable site conditions	Unsuitable conditions
Gross pollutant traps *(Fact Sheet 9)*	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 10)*	Coarse sediment capture Temporary installation Pretreatment for other measures	Need available land area	Proximity to airports because of bird presence
Rainwater tanks *(Fact Sheets 2, 3, 8)*	Storage for reuse Sediment removal in tank	Proximity to roof Suitable site for gravity feed Incorporate to urban design	Non-roof runoff treatment
Vegetated swales *(Fact Sheet 12)*	Medium and fine particulate removal Streetscape amenity Passive irrigation	Mild slopes (<4%)	Steep slopes
Buffer strips *(Fact Sheet 12)*	Pretreatment of runoff for sediment removal Streetscape amenity	Flat terrain	Steep terrain
Raingardens *(Fact Sheet 13, 14)*	Fine and soluble pollutants removal Streetscape amenity	Flat terrain	Steep terrain High groundwater table
Ponds *(Fact Sheet 11)*	Storage for reuse Fine sediment settling Flood retardation Community & wildlife asset	Steep terrain with confined valleys	Proximity to airports, landfill
Wetlands *(Fact Sheet 15)*	Community asset Medium to fine particulate and some soluble pollutant removal Storage for reuse Wildlife habitat	Flat terrain	Steep terrain High groundwater table Acid sulphate soils Proximity to airports because of bird presence
Retarding basins	Flood retardation Community asset	Available space	Limited available space Very flat terrain

Treatment train

A series of treatment measures that collectively address stormwater pollutants is called a 'treatment train'. The selection and order of treatments is a critical consideration. Treatment trains need to consider:

- Removal of coarser pollutants must be removed so that treatments that target fine pollutants can operate effectively
- Proximity of a treatment to its source
- Distribution of treatments throughout a catchment.

Table 6 outlines stormwater treatment measures that form a 'tool kit' from which individual measures can be selected to treat pollutants generated in an urban area.

An overriding management objective can help determine the most feasible stormwater treatment process. As a general rule, site conditions and the characteristics of the target pollutant(s) affect how treatment measures are chosen. Climate conditions, such as the frequency and intensity of storm events, affect the design of treatment systems and the overall effectiveness of pollutant removal.

Figure 15. Stormwater management issues, pollutants and likely treatment processes[13]

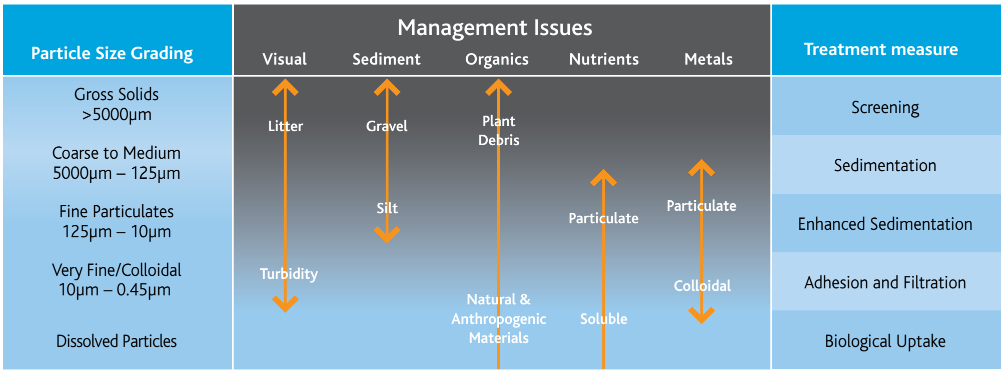


Figure 15 shows the relationship between:

- Management issues
- Likely pollutant sizes
- Appropriate treatment processes for those pollutants.

The horizontal lines through the arrows show the extent of the effectiveness of the treatment processes for each particle size. For example, if the management issue is to control the visual pollution caused by stormwater entering a watercourse, large particles such as litter can only be treated by screening and not by sedimentation or biological uptake. As the pollutant particle size reduces (e.g. for the treatment of soluble nutrients and metals), the nature of the treatment changes. Soil, gravel and vegetation can then provide treatment of soluble pollutants. These are called rain gardens. For more details these methods, refer to *Fact Sheets 13 and 14*.

Figure 16. Pollutant size ranges for various stormwater treatment measures[13]

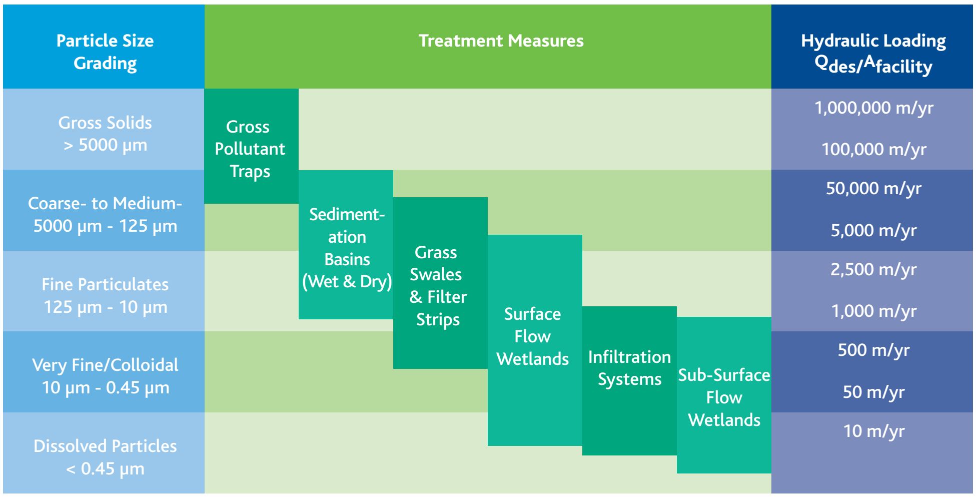


Figure 16 shows the inter-relationship between:

- Stormwater pollutant particle size
- Suitable types of treatment measures
- Appropriate hydraulic loading.

Hydraulic loading is the flow of stormwater through a treatment system. To allow the various pollutant removal processes to occur, treatments such as grass swales, vegetated buffer strips, surface wetlands and infiltration systems require the stormwater to flow through the system for a longer time than gross pollutant traps (GPTs).

GPTs collect litter and debris from stormwater systems through screening (refer to *Fact Sheet 9*). For a given size of unit, GPTs can treat higher flow rates than rain gardens. This means that they use a smaller proportion of land for treatment. The process of pollutant removal, either sedimentation or physical screening, reflects the smaller land size.

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[13] Developed for Landcom's WSUD strategy (2003)

Groundwater

Improving stormwater quality helps to protect our 'surface waters' including the Yarra River, Maribyrnong River, our creeks and Port Phillip Bay.

It is also important to protect our groundwater.

Groundwater in Melbourne is typically low in quality making groundwater extraction unfeasible without extensive treatment. Changes to the built or natural environment should always protect or enhance both groundwater quality and quantity.

Construction work can often disrupt groundwater requiring it to be extracted away from certain sites. Such works generally then require groundwater to be re-injected to prevent any land subsidence.

The management principles for groundwater are:

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

Groundwater users have the responsibility to make sure the groundwater is appropriately managed and protected.

Part 2

Module 2.3

Considering the Environment

Interaction with the broader environment is a key consideration after the site has been assessed for suitability for a sustainable water project.

Recycled water can have several associated environmental risks, including:

- Impact on the aquatic environment
- Impact on the land, primarily from irrigation
- Production of greenhouse gases
- Production of biosolids and other wastes
- Odours.

These risks are site-specific and depend on the:

- Topography, geography and location associated with specific water treatment technology
- End use of the water.

Impact on the aquatic environment

WSUD can help to protect the aquatic environment by reducing:

- Impacts of stormwater outlets into waterways by slowing water velocity and reducing the amount of pollutants in the stormwater (this will in turn protect the natural ecosystem of the receiving waterway or bay)
- Demand for mains water, which in turn reduces the demand from upstream regional waterways that are sourced for Melbourne's water storages
- Local requirements to draw water directly from local waterways
- Inadequately treated wastewater discharging into the aquatic environment.

WSUD will also provide:

- Quality re-use water for additional environmental flows by ensuring there are no elevated nitrogen and phosphorus levels that would contribute to algal blooms
- Additional aquatic environments through WSUD works, including wetlands and ponds
- Water retention within the catchment to help with flood mitigation and reduce the rapid rise and fall of water levels in creeks and streams.

Further information and advice is available in environmental guidelines including:

- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000) *National Water Quality Management Strategy – Paper No. 4 – Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000) *National Water Quality Management Strategy – Paper No. 14 – Guidelines for Sewerage Systems – Use of Reclaimed Water.*
- Department of Environment and Conservation (NSW) (2004) Environmental Guidelines – *Use of Effluent by Irrigation*.

Algal management and water quality

The ability of a waterbody to provide a healthy ecosystem is largely determined by the levels and residence time of excess nutrients and (to a lesser extent) toxins, within both the waterbody itself and the inflowing water.

Excessive blue-green algal growth is a large threat to the health of a waterbody. The exponential rate of algal growth under unlimited conditions means that algal populations can rapidly reach levels where they become a risk to public health and fish and invertebrate growth. Some cyanobacterial (blue-green algae) blooms can be toxic to humans and other biota.

The rate of algal growth is a function of:

- Available nutrients
- Light
- Temperature
- Hydrologic conditions.

When there are enough nutrients, which only need to be in low concentrations, managing residence times becomes critical to managing the risks of algal blooms[14].

Nuisance algal growth and possible algal blooms develop under a combination of factors. Figure 17 summarises these factors in a generic algal growth end-point diagram.

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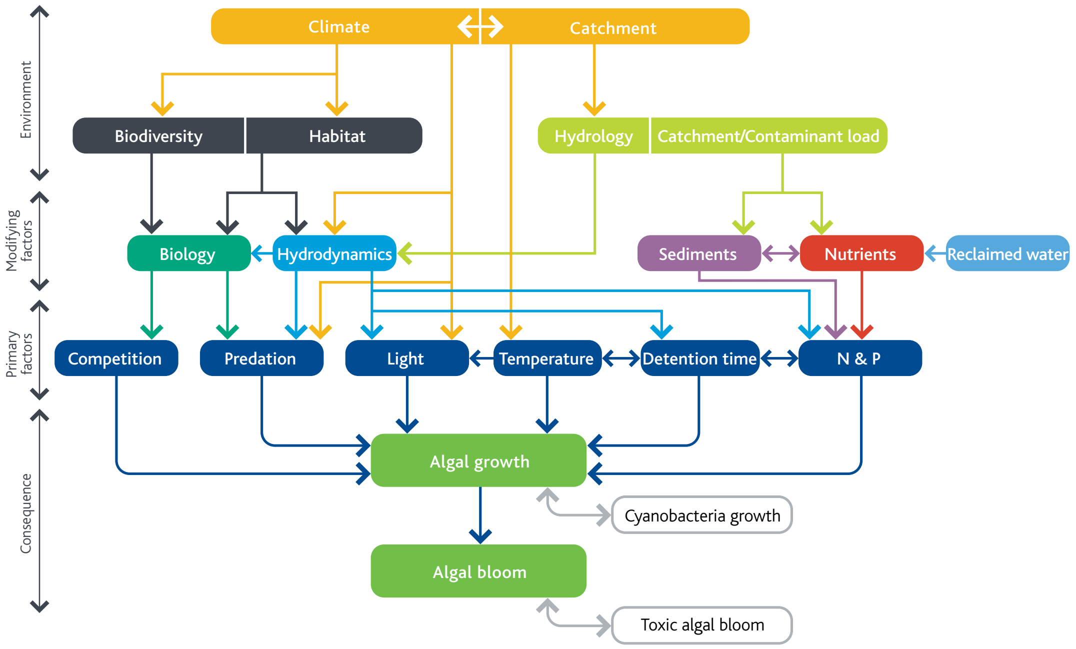
[14] See *WSUD Engineering Procedures: Stormwater*, Chapter 10 Ponds and Lakes (Melbourne Water, 2004) and Burge and Breen (Ecological Engineering, 2006) for more detail.

Figure 17. End-point diagram for algal growth



In summer, algal growth and bloom within waterbodies must be managed through the hydraulic residence time of the lake. 30 days is the maximum residence time for lakes in Melbourne to minimise the risk of cyanobacterial blooms.

Impact on the land primarily from irrigation

Recycled water in urban settings provides water for irrigation. Irrigation provides an appropriate use of recycled water and should not be simply seen as a way of disposing of water.

The suitability of recycled water for a particular environment depends on:
- Soil conditions
- Site topography
- Geology.

Risks associated with applying recycled water for land irrigation in urban and rural settings include:
- Elevated nutrient levels
- Elevated salinity levels
- Excessive sodicity.

Increased salinity from recycled water irrigation has the potential to impede plant growth and degrade soil conditions. The soil structure can also be degraded through soil sodicity due to the high presence of sodium ions relative to magnesium and calcium ions.

Increased nutrient levels will also be present in reused water. If the urban environment has an adjusted botanical landscape from pre-development conditions, it may benefit from the increased nutrient loading. To protect groundwater quality, proper management is needed to ensure minimal nutrients excretion to the groundwater.

Land Capability Assessment (LCA) for irrigation using recycled water

A land capability assessment (LCA) undertaken at the planning phase will be required to assess the suitability of land for irrigation by recycled water.

An LCA is a survey that assesses the capability of a site to sustainably manage the health and environmental impacts of external stressors such as recycled water use. It looks at:
- Soil conditions
- Site topography
- Geology.

For examples of land capability assessment approaches, look at:
- EPA Information Bulletin – Land Capability Assessment for Onsite Domestic Wastewater Management (March 2003) by EPA Victoria
- *Environmental Guidelines – Use of Effluent Irrigation* (2003), by NSW Department of Environment and Conservation (NSW).

An LCA for on-site management of domestic wastewater will help to:

- Identify land areas that are most and least capable for on-site wastewater programs
- Develop a management regime to suit the site, minimising impact of on-site wastewater management and ensuring long-term sustainability.

A four-stage process for assessing land capability for on-site wastewater management includes:

- Stage 1. Develop appropriate LCA criteria
- Stage 2. Gather and collate land inventory information
- Stage 3. Assess land capability
- Stage 4. Develop a management program.

EPA Victoria's approach is summarised in this module. For more detailed information, refer to EPA Victoria's published information on how to carry out an LCA[15].

Soil sodicity

Elevated salinity levels can lead to an increase sodicity level. This can lead to a degradation of the soil properties resulting in soil dispersion.

Sodicity is the complex interaction between soil physical and chemical properties. Sodicity is caused by a relative excess of sodium ions (Na+) in the soil compared to the divalent cations calcium (Ca^{2+}) and magnesium (Mg^{2+}).

When there is an excess of sodium cations, the majority of clay exchange sites in the soil are occupied by sodium ions. If other soluble salts are then leached, the positively charged clay particles repel each other. In particular, this happens during soil wetting, including irrigation.

The soil particles are then dispersed, causing the soil to swell and stopping the movement of air and water through the soil structure. Plants are damaged by sodic soils because swollen soils prevent root growth, leading to potential waterlogging and anoxia.

The application of irrigation water can produce sodic soils. Using water with a high proportion of sodium to calcium and magnesium can also produce sodicity. Clay soils, with a higher concentration of ionic charged surfaces, have a higher risk of developing sodic properties.

Sodic surface soils can be identified by the turbidity and clouliness they create in water.

For large irrigation areas, soil and moisture testing is recommended to secure the best environmental and financial management of this asset.

Production of biosolids

Wastewater contains solids, known as biosolids or sludge. These solids are wastes and require disposal. Disposal can happen through the conventional sewer system or by dedicated sludge processing facilities. The site boundary and surrounding infrastructure determine the options for sludge disposal.

Water reuse aims to extract water from the sewer. Sewer mining applications will dispose sludge and other waste directly into the sewer for centralised treatment. To make sure there is enough flow and avoid odour issues, minimum flows in the sewer must be maintained.

Localised water treatment systems, away from centralised facilities, must be self-contained. Therefore, sludge handling and processing will be required so there are no adverse environmental effects.

Odour control

Untreated wastewater must not be stored. Untreated wastewater not only releases odours, it is also a potential risk to public health.

Odour can be generated by the biological decomposition of wastewater. If untreated and stored, wastewater can turn septic. Treatment for reuse and safe disposal of wastewater is essential.

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[15] EPA Information Bulletin – *Land Capability Assessment for On-Site Domestic Wastewater Management* (Published March 2003) provides further information.

Part 2

Module 2.4

Being Carbon Sensitive

This module looks at the greenhouse gas emissions of different water sensitive urban design (WSUD) projects. It follows industry best practice and relevant government programs and regulation.

The 'carbon sensitive' framework measures, reduces and offsets the greenhouse gas emissions from the following aspects of a WSUD project:

- Energy use
- Biodegradation processes
- Embodied energy emissions.

When it's not possible to reduce all of the emissions associated with a WSUD project, offset the additional emissions from the main sources.

This module helps Councils to:

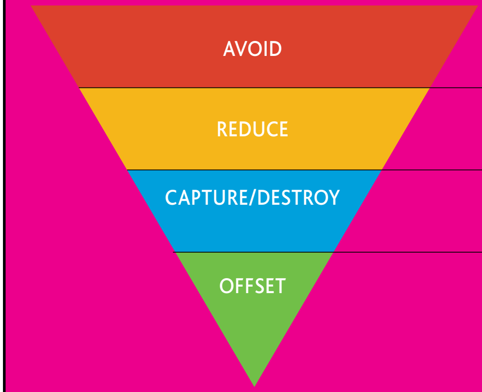
- Compare the greenhouse impacts from alternative water schemes
- Identify material sources of emissions and options for the purchase of greenhouse gas offsets.

Insert any information you have on your Council's policy or approach taken to minimise greenhouse gas emissions in the area of sustainable water management, or other relevant Council areas. If your Council has not yet developed an approach, this module will help.

Greenhouse gas management hierarchy

In order to be carbon sensitive, a greenhouse management system will need to be implemented reflecting the hierarchy of actions outlined below in Figure 18.

Figure 18. The greenhouse gas management hierachy



Avoid the activity (e.g. demand management measures, selection of drought tolerant plant species) or seek low emissions inputs such as recycled material or renewable energy

Reduce the emissions intensity of the activity through efficiency programs (e.g. efficient equipment) or fuel switching (e.g. electricity to natural gas)

Capture and store (e.g. tree planting) or destroy emissions (e.g. harvesting biogas)

Procure and retire carbon credits

First, strive to avoid or reduce emissions. This is a feature of the most effective greenhouse gas management systems. Reducing or avoiding emissions can often happen at low or zero net cost per tonnes of emissions abatement. Next, switch to greener fuel sources. Finally, consider the use of offsets.

Purchasing offsets alone is not a recommended option for greenhouse gas management systems, either economically and environmentally. Relying on purchased offsets (the last step in the hierarchy) does not prevent the greenhouse impacts in the first place, and increases exposure to financial risk, both through price volatility in offset markets and increases in energy costs.

Scale of greenhouse issue relevant to WSUD Treatment

As a general message, the greenhouse emissions from most WSUD treatments are minimal. For example:

- to run the Royal Park Wetlands stormwater harvesting and reuse system for a year generating 134 ML for reuse is equivalent to same amount of greenhouse gases emitted by six average Victorian households;
- to harvest rainwater at Queen Victoria Markets and reuse in the public toilets for a year generating 5.2 ML for reuse is equivalent to the same amount of greenhouse gases emitted by one quarter of an average Victorian household.

The greenhouse emissions from desalination and other advanced technology such as reverse osmosis are much higher. For example:

- a membrane sewer mine used for a 9 storey office building emits the equivalent greenhouse emissions as 21 average Victorian households over the course of a year.

Hierarchy of WSUD treatment based solely on greenhouse impact

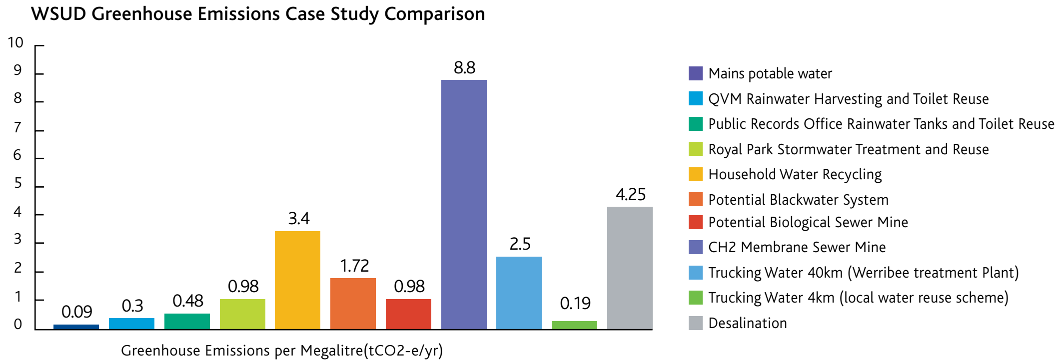
In summary, the greenhouse efficiency of different WSUD treatments (based on limited case study analysis and not including the treatment of wastewater) is set out in the following order:

1. **Potable mains water** – greenhouse efficiencies exist as one of the benefits of potable water being provided by a large, established, gravity fed centralised water supply system.
2. **Rainwater harvesting** – the limited need for treatment helps to reduce the greenhouse requirements for rainwater harvesting, and good design can also reduce the need for pumping to transport water on site.
3. **Stormwater harvesting** – energy needs for stormwater harvesting are primarily needed for distributing water, with less needed for treatment as this can happen through soil filtration. Efficiencies can be delivered through the large scale of stormwater harvesting systems.
4. **Biological sewer mining** – recent advances in sewer mining to draw on biological treatment has made this option more greenhouse efficient particularly as it can deliver large quantities of treated water.
5. **Blackwater recycling** – recent advances enable system operators to have more control over the quality of the blackwater that is being treated. This means that the level of filtration can be moderated to produce fit-for-purpose reuse water, saving on pumping and energy requirements.
6. **Trucking water** – is greenhouse intensive when delivered over large distances such as from the Werribee Treatment Farm. It is much more efficient if delivered from a local water reuse scheme, however would need to include emissions from the treatment itself to be a fair comparison.
7. **Household water recycling** – this is a greenhouse intensive way of delivering potable water savings because of the small amount of water that is delivered by the system.
8. **Desalination** – this is greenhouse intensive due to the technology used which includes either membrane processes such as reverse osmosis, or thermal distillation.
9. **Membrane sewer mining** – this is very greenhouse intensive due to the pumping required in removing pollutants through membrane filters.

It is important to remember that greenhouse emissions are only one factor in considering WSUD treatment options.

The following analysis of the greenhouse emissions of different WSUD treatments is based on limited data available, and it is hoped that future analysis will provide a more rigorous comparison of the greenhouse emissions of such treatments.

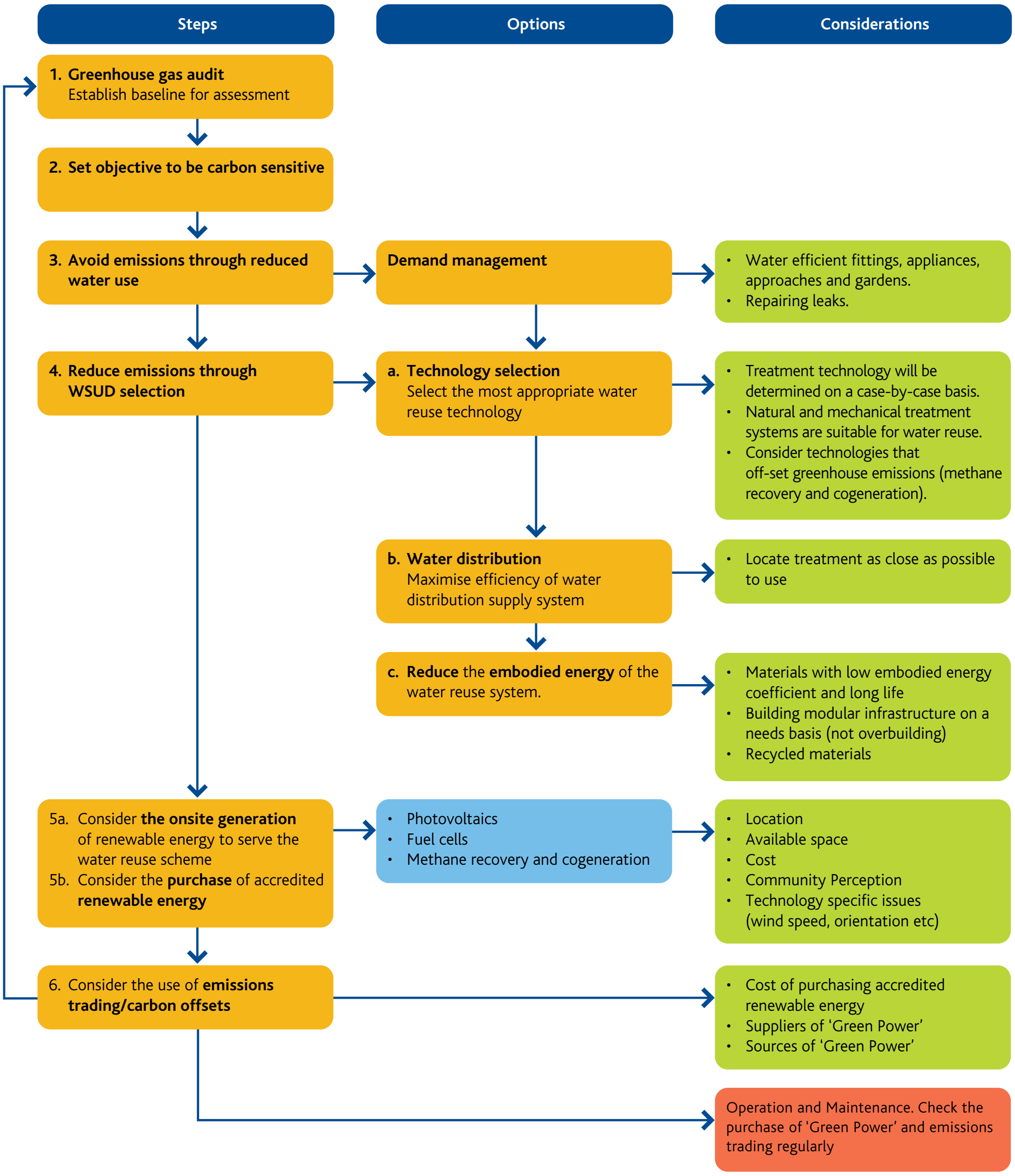
Figure 19. Case study comparison of greenhouse emissions from different WSUD treatments



Carbon sensitive WSUD project framework

Figure 20 shows a best practice greenhouse gas management system for a WSUD project. Using these steps, you can measure and reduce the greenhouse impacts of a WSUD project before planning the offset options that can take place on an annual basis as the project progresses.

Figure 20. Steps to a carbon sensitive WSUD project



Step-by-step: A carbon sensitive WSUD framework

Step 1 – Measure emissions

Preparation is needed to compare the level of greenhouse gas emissions from the current system with new, alternative WSUD projects. Full greenhouse gas inventories of the collection, treatment and transport of Melbourne's mains potable water and alternative WSUD options are required.

This applies to projects at a range of scales, from the household rainwater tank to larger water reuse projects. All emissions from electricity use should be included, as well as emissions from wastewater treatment.

Step 2 – Set objectives

Targets should be set for reducing greenhouse emissions based on an assessment of opportunities for reductions. Council Name's Greenhouse Strategy name sets greenhouse reduction targets and key opportunities for consideration as part of this step.

Step 3 – Reduce water use to avoid emissions

The most efficient way to avoid emissions from WSUD projects is to reduce water demand. Reducing water demand means that emissions from supplying water and subsequent wastewater treatment are reduced.

Step 4 – Reduce emissions through WSUD selection

Consider greenhouse emissions from WSUD options by accounting for emissions from:

- Operating the WSUD treatment
- Distributing water from the WSUD treatment
- Embodied energy within the WSUD treatment.

Step 5 – Consider the on-site renewable energy generation and accredited renewable energy

Consider:

- On-site renewable energy generation to power the WSUD projects – options include photovoltaics or cogeneration from biogas
- Purchase of renewable energy accredited to government standards – generally considered to have more greenhouse benefits than other offsets such as from methane flaring or energy efficiency, as it supports investment in energy infrastructure not reliant on fossil fuels.

Step 6 – Assess residual emissions and offset purchasing

For the remaining emissions that cannot be reduced by the above methods, purchase carbon offsets from the market.

Step 1: Develop a greenhouse gas inventory

A full greenhouse gas inventory must be prepared for all emissions associated with the collection, treatment and transport of Melbourne's mains potable water. This includes current or 'business-as-usual' and alternative WSUD projects. Projects should cover a range of scales, from the household rainwater tank to larger water reuse projects.

By preparing both inventories, it's possible to quantify the additional greenhouse gas emissions generated from the new WSUD projects. This can then be compared to the 'business-as-usual' baseline. Use the same methodology for both project types.

Calculating greenhouse gas emissions

The greenhouse gas emissions from a water supply and treatment system or project are the sum of emissions from:

1. Electricity consumption from the water consumed and wastewater generated
2. Biological degradation of wastewater
3. Embodied energy from materials selection.

1.1 Electricity consumption from the water consumed and wastewater generated

Emissions are generated from the electricity consumed by all the processes associated with the transportation and treatment of potable water and wastewater. These are classed as 'indirect scope 2' emissions as they were emitted by the utility companies that produced the electricity. More information is available in the definition of emission sources (weblink to definition of emission sources).

To calculate greenhouse gas emissions, emission factors are applied to the energy consumed.
The factors depend on:

- Where the electricity was generated (the state or territory)
- Fuel source used (for Victoria, this predominately from non-renewable, brown coal-fired power stations).

Water is typically used once and wastewater is generated. The wastewater is then transported long distances and more energy is used for treatment prior to discharge. These are 'indirect scope 3' emissions as they are emitted by the water utility company that has produced the water.

The water utilities produce figures for the greenhouse gas emissions for supplying potable water and treating wastewater. These are listed below in Table 1. A water balance is prepared for a WSUD project before the greenhouse gas inventory. This quantifies:

- Total water use
- Wastewater generation of the site.

Using baseline water consumption, greenhouse gas emissions can be calculated for a 'business-as-usual' case (i.e. without the water saving scheme). This is achieved by applying emission factors to the total consumption.

Table 8 shows greenhouse gas emissions for water and wastewater per mega litre supplied to Melbourne. Melbourne Water provided these figures for the 2006/2007 year[15], based on emission factors that are calculated annually. These figures will be updated annually on the Melbourne Water website using information provided by the water utilities companies.

Table 8. Greenhouse gas emissions for water and wastewater in Melbourne

Water	Equivalent CO_2 generated (CO_2t/ML)
Potable Water	0.09
Wastewater	0.74

1.2 Biological degradation of wastewater

Greenhouse gas emissions are produced by the biological treatment of wastewater. The organic loading that needs treatment mainly comes from faecal matter. Kitchen and laundry waste produces other organic matter. In Melbourne, greenhouse gas emissions are minimised by the capture and reuse of biogas to power the wastewater treatment process.

Further instructions for calculating biological degradation emissions are available in the City of Melbourne WSUD Carbon Sensitive Framework Guidelines.

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[15] The figures are an average for the entire distribution system for water supply and wastewater disposal including the greenhouse gas abatement strategies that are relevant to the supply of water to City West Water. They exclude greenhouse gas emissions from offices and company vehicles. No greenhouse gas were supplied from City West Water as they had a 'zero net greenhouse emissions', meaning that their emissions were offset or reduced through renewable energy purchases.

1.3 Embodied energy emissions from materials selection

It's also necessary to consider how much energy is used in the production of the water treatment system. This embodied energy is determined by a life cycle analysis. Table 10 in Step 4.3 shows the embodied energy of some common materials.

In general, the embodied energy of a product can be reduced by:
- Selecting appropriate materials with a low embodied energy coefficient and longer life expectancy
- Building modular infrastructure on a needs basis (not overbuilding)
- Using locally sourced materials where possible to minimise transport related carbon emissions
- Considering the use of recycled material (the embodied energy in recycled materials is generally less than new materials).

This is set out in greater detail in Step 4 of this WSUD Carbon Sensitive Framework Module.

Carbon calculator

City of Melbourne has developed a carbon calculator to help measure baseline carbon emissions from WSUD projects, using the three emissions sources described previously. Using generic project templates, you can enter details about the size of the system and the material contents. Greenhouse gas emissions are then calculated based on the methodology above.

Definition of emission sources

A greenhouse gas inventory should identify:
- Direct emission sources from operations
- Indirect emission sources from the consumption of purchased energy, such as electricity.

The *Greenhouse Gas Protocol* (Revised Version, 2004)[16] is an internationally-recognised protocol that defines emissions as:
- Scope 1
- Scope 2
- Scope 3.

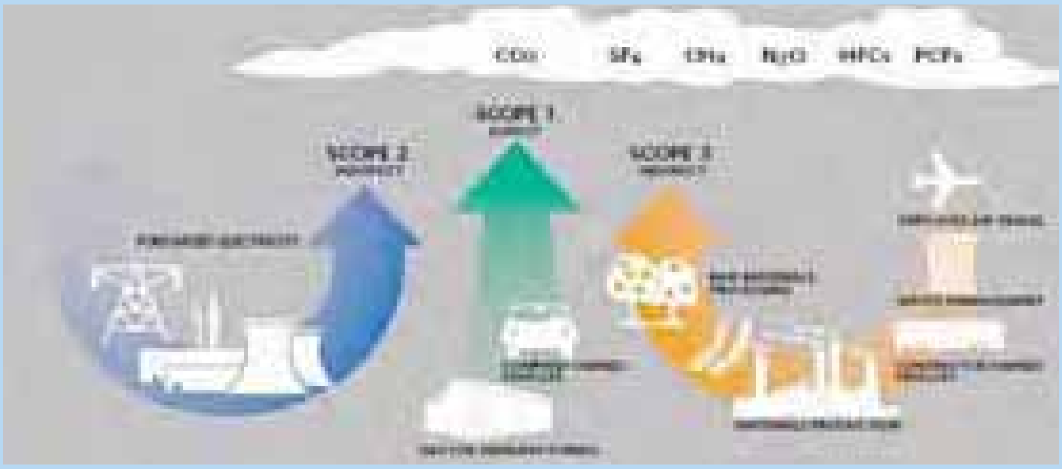
Scope 1 emissions are direct greenhouse gas emissions from sources that are owned or controlled by a company. For example:
- Emissions from combustion in boilers and vehicles (water tankers)
- Emissions from biodegradation of wastewater.

Emissions from combustion of biomass or those that are not covered by the Kyoto Protocol (CFCs etc.) are not included in scope 1.

Scope 2 emissions are indirect greenhouse gas emissions from the generation of electricity, steam and heating/cooling purchased or otherwise brought into the organisational boundary of the company, and consumed by the company. Scope 2 emissions physically occur at the facility where electricity or steam is generated.

Scope 3 emissions are all other indirect greenhouse gas emissions that are from sources not owned or controlled by the company, but occur because of the activities of the company. For example:
- Extraction and production of purchased materials
- Transportation of purchased fuels
- Use of sold products and services.

Figure 21. Emissions scope definition (Source: New Zealand Business Council for Sustainable Development)



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[16] See Chapter 4: Setting Operational Boundaries (www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf)

Step 2: Set objectives

Targets can be established once the greenhouse gas inventories have been completed for the 'business-as-usual' option and the alternative WSUD projects. Targets set realistic goals and help assess opportunities for reducing emissions.

The Council Name's Greenhouse Strategy name sets greenhouse reduction targets and key opportunities for consideration as part of this step.

The boundary definition for the Council water infrastructure is critical when establishing the objectives. Both direct (scope 1) and indirect (scope 2 and 3) emissions must be included within the boundary in a carbon sensitive scheme.

Figure 22. Boundaries for emissions for business-as-usual and for the WSUD project using Council Name as an example

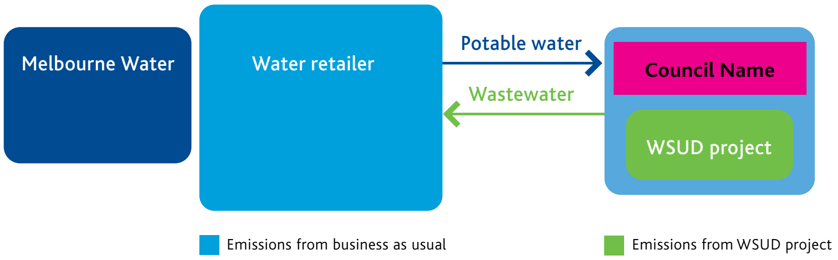

Figure 22 shows the boundaries for emissions from a business-as-usual case and from a WSUD project.

Business-as-usual

Council is supplied potable water from its water retailer, and sends wastewater back to the retailer for treatment by Melbourne Water. Therefore, under business-as-usual, the boundary for emissions includes:

- The water retailer(s)
- The portion of Melbourne Water services to these water retailer/s.

WSUD project

The WSUD project will be located within the Council area. Therefore, the boundary for its emissions is its physical boundary which includes:

- A single site (i.e. rainwater tank), or
- A series of activities (i.e. rainwater tank plus distribution system).

Assumptions are listed below.

Water sources for the WSUD project will either be from:

- Mains water supply, wastewater (greywater reuse, blackwater, water mining)
- Rainwater harvesting
- Stormwater harvesting.

Water leaving the water saving scheme will either be wastewater back to the mains or to the natural environment through seepage, evapotranspiration or stormwater.

There are no associated emissions with natural processes such as evapotranspiration. Therefore the emissions of water entering or leaving the water saving scheme will be from (where applicable) the emissions associated with the water retailer(s) and Melbourne Water Corporation.

Step 3: Avoid emissions – reduce water use

The most effective way of reducing greenhouse emissions is to reduce water use in the first place. Greenhouse gas emissions associated with water treatment can be minimised by:

- Reducing water consumption and wastewater generation
- Reducing organic material in wastewater (e.g. by educating commerce and industry about waste minimisation and cleaner production)
- Diverting organic waste from uncontrolled anaerobic conditions, such as leaf litter from rainwater tanks.

3.1 Reduce water consumption

Reducing demand also reduces the energy needed to move water across large distances. This includes transport to and from:

- Locations where water is stored for use
- Wastewater treatment plants where water is treated and disposed.

Importantly, less energy is also required to heat (for hot water), treat and transport water to and from the site.

Demand management measures include:

- AAAAA rated water efficient fittings (5A taps, 6/3L dual flush toilets, waterless urinals)
- AAAAA rated water efficient appliances (5A washing machines)
- Water efficient gardens (xeriscaping, hydrozoning, smart irrigation techniques)
- Flow reduction valves.

Demand management measures also encompass surface changes. As well as landscape and turf species changes water reduction can be achieved through synthetic surfaces although consideration needs to be given to other environmental factors such as embodied greenhouse emissions (see Step 4 of this *WSUD Carbon Sensitive Module*).

3.2 Reduce organic material in wastewater

Avoid disposing organic material, for example food scraps or vegetable peelings, into the wastewater system. Greenhouse gases are produced by the biological decomposition of organic matter. This is mostly human waste, but kitchen waste such as food scraps, oils and vegetable peelings also contribute to the overall loading which requires subsequent treatment.

In industrial applications, review operations and auditing processes to reduce organic loadings. Due to a wide range of activities and operations, individual strategies are appropriate in this context.

Step 4: Maximise the efficiency of the system

4.1 Treatment selection

Treatment is needed to upgrade water quality for the appropriate end use. Typically, water used within the city will be treated to a high standard due to the type of water reuse. A range of water sources are available for integrated water resource management as shown in Table 9.

Table 9. Water source and level and treatment

Water	Treatment
Rainwater	Minimal treatment required.
	Hotwater system (e.g. gas boosted system) can be integrated to provide thermal disinfection. Alternatively UV disinfection may be installed.
Stormwater	'Best practice' treatment required. Typically this is through the use of natural treatment systems such as bioretention systems or constructed wetlands.
	Mechanical systems, e.g. filtration systems, can also be used for stormwater treatment. Particularly for large scale systems where limited space is available for treatment.
Greywater	Diversion devices can be fitted to subsurface irrigation systems with no treatment required.
	Household greywater reuse treatment systems can be used for reusing water.
	Moderate treatment is required to ensure pathogens are removed from greywater for non-potable water reuse.
Blackwater/ sewer mining	High level of treatment is required to remove pathogens and biological components to ensure water is safe for reuse.
	Mechanical treatment systems are typically used in cities due to the limited space available.

4.2 Distribution and supply system

Maximise the efficiency of the water reuse systems through the distribution and supply system. WSUD identifies smaller, localised, modular treatment technologies, where the end use of the water is close to the treatment system. In contrast, centralised treatment means wastewater has to be transported to a treatment plant and then transported back to the consumer for reuse. This extensive transport is expensive and energy intensive due to the piping and pumping required.

Minimise energy requirements by:
- Locating treatment as close as possible to the end user and relying on gravity where possible – this minimises resource consumption (piping) and energy requirements (less need for pumping)
- Using header tanks for water supply – these can be fed by low flow trickle pumps
- Selecting energy efficient pumps and motors.

Trucking

In response to the current drought and water restrictions, there has been a significant rise in the amount of recycled water that is being transported throughout Melbourne and beyond by trucks. The trucking of water will reduce the use of potable water, but it is an energy intensive way of accessing water.

The greenhouse emissions associated with trucking water are primarily from fuel use. Most trucks currently use diesel fuel with emissions highly dependent on the load, distance travelled and the frequency of trips. The alternatives for fuel use in these trucks include biodiesel, LPG and petrol.

Trucks used for delivering water are generally categorised into two sizes. These are:
- Small (rigid truck) – 7,500 litres
- Large – 25,000 litres.

The emissions generated from one large truck travelling from Werribee Treatment Farm to central city (40km trip) to water a park with a demand of 50 ML/y will be 2.5 tCO_2e/y per megalitre of water. As with all alternative water sources this is much higher than the greenhouse emissions from mains water (at 0.09 tCO_2e/y per megalitre) and higher than local rainwater and stormwater harvesting schemes with reuse. The emissions for trucking water over this distance is often higher than the latest technology for blackwater recycling and sewer mining[17]. This comparison can be seen in Figure 21.

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[17] These comments are based on a small sample base with best available data to date.

Trucking from within the local area (within 4 kms) reduces the emissions down to 0.19 tCO_2e/y per megalitre of water. This is significantly more greenhouse efficient in terms of vehicle emissions, but will always be combined with the emissions from the local recycled water source itself. For example if the water was sourced from the Royal Park Wetlands then it is necessary to include the emissions from this stormwater system which are measured at 0.98 tCO_2e/y per megalitre of water. Trucking this local source of alternate water emits about half of the greenhouse emissions than trucking it from the Werribee Treatment Plant.

4.3 Embodied emissions in materials selection

It's also necessary to consider how much energy is used in the production of the water treatment system. This embodied energy is determined by a life cycle analysis. Table 10 below shows the embodied energy of some common materials.

In general, the embodied energy of a product can be reduced by:
- Selecting appropriate materials with a low embodied energy coefficient and longer life expectancy
- Building modular infrastructure on a needs basis (not overbuilding)
- Using locally sourced materials where possible to minimise transport related carbon emissions
- Considering the use of recycled material (the embodied energy in recycled materials is generally less than new materials).

Table 10. Process energy requirement embodied energy of common materials[18]

Material	PER Embodied Energy (MJ/KG)
Hardboard	24.11
Cement	6.8
PVC	77.2
Glass	18.5
Aluminium	118.8
Copper	67.22
Galvanised steel	35.8

The type of material used in a pipe is an important factor for water reuse systems. Basic factors[19] that influence the embodied energy impact of a piping system include:
- Size – the bigger the pipe, the more embodied energy
- Amount of materials – the more materials used, the higher embodied energy
- Recycled material – pipes produced with significant recycled materials usually have a lower overall embodied energy
- Embodied energy coefficient – materials with a lower coefficient have a lower embodied energy
- Durability – piping systems with a longer life expectancy mean less repair and replacement, leading to lower embodied energy over the life cycle of the system.

Relative scale of embodied emissions

Generally the embodied energy emissions arising from WSUD treatments are small when compared to the emissions generated from operating the system.

Table 11 shows examples of the impact of embodied energy on the total carbon footprint for WSUD treatments.

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[17] Inventory of Carbon and Energy Version 1.5 Beta, Prof. Geoff Hammond and Craig Jones, Department of Mechanical Engineering, University of Bath, UK

[18] CSIRO Manufacturing and Infrastructure Technology

Table 11. Process energy requirement embodied energy of common materials

WSUD Treatment	Annual emissions from technology (tCO2-e/yr)	Annual emissions from distribution and supply system (tCO2-e/yr)	Emissions from embodied energy (tCO2-e/yr)	Total megalitres treated annually (ML)	Embodied energy contribution to total emissions	Annual emissions from embodied energy per ML treated (tCO2-e/ML)
Royal Park Wetlands Large Stormwater Harvesting and Reuse Scheme	0.0	71.3	0.044*	73	0.06%	0.0006
CH2 Sewer Mining Proposal for Office Building	225	26	1.59**	28.6	0.63%	0.056
QVM Large Underground Rainwater Harvesting and Reuse Scheme	0.0	2.25	0.82*	10.2	36%	0.08
Public Record Office Above Ground Office Rainwater Tanks	0.0	1.3	0.012*	2.7	0.9%	000.4

* using a conservative estimated design life of 10 years **using a 50 year design life

The greater embodied energy contribution will be seen from those WSUD treatments that require significant materials, reticulation and associated equipment. However, studies to date show that the range of WSUD treatments are all less than 0.1% of total emissions per ML treated over the life of the scheme.

Each WSUD treatment will be different and project designers should use the Carbon Calculator to calculate their own emissions.

Embodied energy of synthetic turf

The use of synthetic turf as a water saving measure also needs to consider embodied energy based on its production, installation and transport. Consideration also needs to be given to the disposal and/or recycling of these materials once they have reached the end of their useful life.

A study[20] has been undertaken in Canada to estimate these emissions. Calculated emissions would be higher when translated to Victoria due to the use of brown coal as the primary energy source (which comparatively emits more greenhouse emissions).

Benefits associated with synthetic turf include water conservation through reduced irrigation, and the ability to use the surface as a catchment to harvest stormwater for reuse. Synthetic turf does absorb sunlight and emit heat, and performs best when established with some trees and shading to diminish the possible heat island effect in a time of climate change.

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[20] City of Yarra (2008) The Environmental Impact of Synthetic Turf Relative to Natural Turf Playing Fields.

Step 5: Consider renewable energy

On-site generation of renewable energy

Generating renewable energy onsite helps to avoid greenhouse gases. After finishing a greenhouse gas inventory and improving system efficiency, greenhouse gases may still be produced. On-site generation of renewable energy can negate or offset these emissions.

Renewable energy uses natural resources that can be replaced or 'renewed'. These resources don't contribute to the greenhouse effect or global warming. Renewable energies include but are not limited to:

- Photovoltaics
- Wind
- Fuel cells
- Methane recovery and cogeneration.

Renewable energy prevents greenhouse gases in the first place and is therefore a better environmental solution than relying on purchasing offsets after emissions have been produced.

Ideally all energy use should come from renewable sources, however with current disproportional cost of renewable energy it is considered that requiring 20% of energy needs to come from renewable sources will help to mitigate emissions, grow the renewable energy market and help contribute to the Federal mandatory renewable energy target of sourcing 20% of energy needs from renewable sources by 2020.

Photovoltaics

Photovoltaic (PV) cells convert light energy from the sun directly into direct current (d.c.) electricity. An inverter converts this into alternating current (a.c.) electricity for use[21].

Currently, photovoltaics are expensive. The exception is specialist applications where connecting to the electricity grid would be comparatively expensive, for example in a large park. However photovoltaics will become a more attractive economic alternative as efficiencies increase and costs decrease.

Solar powered water pumps are commercially available and are an option for small to medium pumping applications that are not demand dependant.

Wind

A wind turbine generator consists of a:

- Foundation
- Tower
- Nacelle
- Rotor (blades on a central hub).

The rotor turns a generator, converting some of the wind's energy to electricity. As wind speed increases more energy is delivered to the rotor.

Within metropolitan Melbourne, there are a number of factors to consider when using wind power to fuel water recycling. These include:

- Location – wind farms are generally located where there is a good wind resource, local community support and plenty of open land available[22]
- Wind speed – an average annual wind speed of 5m/s for Melbourne has been modelled using the WindScape wind resource mapping tool[23], which is below the optimal wind speed for generating electricity (according to the Australian Wind Energy Association)
- Noise – wind generators in urban areas have turbines mounted on a tower and make some noise in operation (according to the Australian Greenhouse Office (AGO)).

Fuel cells

Fuel cells convert energy from chemical reactions directly into electrical energy. They are cleaner and more efficient than any carbon fuelled engine, however as yet they are not greenhouse neutral.

Fuel cells can be cost competitive with engine driven and turbine power plants. This was found by comparing molten carbonate fuel cells with three conventional approaches for recovered methane use (heat recovery, energy generator and natural gas production)[24].

Today fuel cells typically need hydrogen as a fuel source. Creating hydrogen usually needs energy, which can have greenhouse implications. However, there are some trials with fuel cells running on natural gas provided by the existing mains network. This system will create up to 90% of the building's hot water needs with close to zero greenhouse gas emissions[25].

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[21] SEAV, 2004.

[22] AWEA, 2004

[23] Developed by the Wind Energy Research Unit of CSIRO Land and Water

[24] CH2M Hill (1997)

[25] www.ourgreenoffice.com

Methane recovery & cogeneration

When biological systems are used, greenhouse gases can be generated from the water treatment process[26]. Biogas (predominately methane) can be collected in these situations and used to operate co-generation plants which provide energy to the treatment plant. Excess energy can be supplied to the electricity grid.

Methane is collected and used as an energy source at a number of wastewater treatment plants including those run by Melbourne Water. When methane is captured and reused as a fuel source, it:

- Prevents methane from being discharged into the atmosphere
- Reduces reliance on traditional energy sources including electricity and gas.

Biogas recovery systems improve efficiency of current practices. However there will still be a residual greenhouse impact associated with burning the methane to generate power. Carbon dioxide is released by the combustion of biogas (predominately methane) and this will need to be offset.

The WSUD Carbon Sensitive Framework Guidelines provide further explanation about these issues.

Consider the purchase of accredited renewable energy

If there are greenhouse gas emissions from the water saving process after you've taken the steps above, you must consider the purchase of Green Power™ from an accredited electricity supplier.

Council considers that purchasing renewable energy is a better environmental outcome than relying on carbon offsets to mitigate emissions once they have occurred. Unlike offsets, renewable energy prevents emissions from occurring in the first instance. It would be ideal to purchase all energy needs from renewable sources, however in acknowledgement of the current higher costs of renewable energy it is considered that a proportion of energy purchased from renewable sources is an adequate contribution.

In light of this, Council requires 20% of the electricity to be Green Power™. The 20% contribution is equal to the current mandatory renewable energy target set by the Federal Government.

Ask the energy retailer for proof that their product is currently an accredited Green Power™ product, or check that their product displays the Green Power Accreditation.

GreenPower™ (accredited renewable energy)

Electricity customers can purchase a specific amount of Green Power™ from electricity suppliers. The retailer then has to source an equivalent amount of energy from wholesale renewable energy generators such as wind, solar and hydro-power, instead of sourcing it from coal fired generators.

The National Green Power Program "aims to drive investment in renewable energy in Australia with a view to increase the sustainability of Australia's electricity supply. This will be achieved by raising awareness of, and ensuring consumer confidence in, accredited renewable energy products and increasing their uptake".

The Accreditation Program sets out technical criteria, marketing criteria and eligibility requirements for energy products to be included in the scheme. The retailer of the energy products must provide quarterly and annual information to ensure the criteria and requirements are being met.

The Green Power Scheme, including its accreditation process, is overseen by a national steering committee. This group has representatives from the lead State Government agency working in renewable energy issues in each state. Currently, this is the only scheme in Australia that has a:

- Clear framework to ensure consumer confidence
- Robust and transparent accounting process
- Mechanism which links consumer demand to stimulating growth of renewable energy infrastructure in Australia.

Visit www.greenpower.com.au for more information.

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[26] Radcliffe, 2004

Step 6: Assess residual emissions and purchase offsets

Purchasing carbon offsets should be the last step to minimise greenhouse gas impacts. It's only appropriate after all other avenues, such as avoidance or reduction of emissions, have been used.

Carbon offsets are 'credits' for greenhouse gas abatements achieved by other organisations. For example, energy efficiency or renewable energy projects can generate carbon credits. Currently there are many providers of carbon credits that have been certified under numerous voluntary and government programs.

In general, each carbon credit is equal to the abatement of 1 tonne of carbon dioxide equivalent gases (tCO_2 equivalent). However, there are many ways that carbon credits can be generated and/or accredited. It's up to the project manager to choose which carbon credit is most suitable.

Evaluation of greenhouse gas abatement

Use the following evaluation criteria to select options:

- Cost – measured in terms of $/tonne greenhouse gas abated
- Certainty of delivery – contractual certainty
- Adaptability to future policy and market environments – will the offsets be eligible under a future emissions trading scheme
- Management – complexity of implementation
- Transparency and verifiability of abatement
- Communications – how can abatement be articulated to stakeholders
- Environmental benefit – in terms of emissions reduced.

Part 2

Module 2.5

Considering Life Cycle Costs

Economic analysis of a water sensitive urban design (WSUD) project needs to consider the total costs to the community. A life cycle costing approach considers the total cost over the life of the project. This module defines what life cycle costing is and how it can be applied.

What is life cycle costing?

Life cycle costing (LCC) is a process used to determine the sum of all expenses associated with a product or project. It's a structured approach that looks at all of the elements of a project's cost.

The key components to a life cycle costing evaluation are:

- Capital expenditure
- Installation
- Operation
- Ongoing maintenance and labour costs
- Replacement costs and timing for significant expenditure
- Life span
- Decommissioning costs.

When should life cycle costing be used?

LCC allows you to compare total costs over the lifetime of a WSUD project with other options. It provides an important economic indicator for the selection of WSUD opportunities.

LCC can be used to produce a spend profile over the anticipated life span of a project. When there are several options to choose from, the results of an LCC analysis can help managers to make decisions.

The accuracy of LCC analysis diminishes as it projects further into the future, so it's most valuable as a comparative tool when long term assumptions apply to all the options and therefore have the same impact.

How is it calculated?

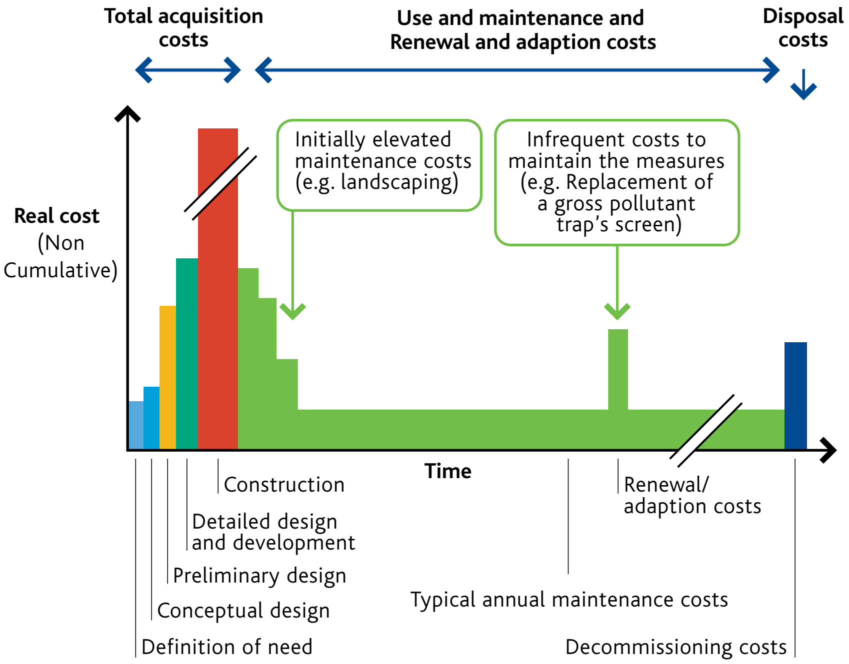
LCC is the sum of all 'discounted costs' over the life cycle of the project. It's expressed in dollars relevant to the 'base date', which is typically the current date. A typical life cycle cost is over a 50-year period.

All costs are discounted to the base date using an appropriate discount rate. A 'real discount rate' is used for discounting future costs that are expressed in real terms relative to a base date.

An LCC for a WSUD project should include all the indicative costs. This provides the base information for analysis. As water reuse technologies and their commercialisation are developing quickly, costs are expected to decrease.

Figure 23 shows the cost elements which are incorporated into life cycle costing.

Figure 23. Life cycle costing elements



Source: Gold Coast City Council; Land Development Guidelines, Section 13.2[27]

MUSIC modelling

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is a tool for simulating urban stormwater treatment trains to estimate their performance. MUSIC can also assist in estimating WSUD lifestyle costing by providing cost data for different stormwater treatment measures, based on lifecycle assumptions. The MUSIC User Guide provides further guidance on the lifestyle data costing. A lifecycle cost assessment customised to the particular system in question should be undertaken for a more reliable result.

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[27] Land Development Guidelines, Gold Coast City Council, Section 13.2 WSUD Conceptual Design: http://www.goldcoast.qld.gov.au/attachment/planningscheme/wsud_13_2_conceptdesign.pdf

Part 2

Module 2.6

Assessing the Risks

This module outlines a risk management framework to enable safe and sustainable water recycling schemes in metropolitan Melbourne. The information in this module is extracted from the *WSUD Risk Management Guidelines* which provide further detail and useful tools to support decision making.

This module provides a summary of risk management for WSUD projects.

Project managers should also use the detailed *WSUD Risk Management Guidelines* when implementing WSUD projects.

Protecting public health and the environment is paramount when alternative water sources are being used. Careful planning, construction and monitoring are required to make sure recycled water is safe.

The framework is designed to support straightforward risk management for simple projects, and a comprehensive approach for more complex projects and those that carry higher risks.

It can be used by Councils and by community, including developers and commercial and industrial businesses.

Tools for risk management at a household level are also included, so it's relevant to those with an interest in small scale domestic schemes.

Managing risks associated with water sensitive urban design

Water sensitive urban design schemes present public health, environmental and institutional risks. Identified risk exposures are detailed below. A more detailed outline of risks is provided in the *WSUD Risk Management Guidelines*.

People

Risks to human health can be caused by poor planning, design and maintenance of water schemes.

Environmental

Unauthorised discharge to the environment causing ecological risks to flora, fauna and soils can be triggered by poor planning, design and maintenance.

Financial and economic

Projects can become financially unfeasible due to poor design. This can lead to the abandonment of infrastructure and a particular initiative. In addition, management of peak flows (i.e. flood prevention) is necessary for safe conveyance of flows and protection of property.

Liability

The City is now playing a role in water treatment and supply and has compliance and due diligence requirements. Treatment failure and poor risk management processes can result in non-compliance and risk for public liability and contractual liability.

Reputation

The City aims to be recognised as a leader in integrated water management. Any of the above risk exposures can impact on community trust.

Managing these risks is not purely achieved by regulation and managing assets and hazards. Ensuring communication and consultation between all stakeholders throughout the planning, design, implementation and management phases of a water recycling scheme is also critical.

Current risk management legislation and guidelines

A risk management approach specific to water schemes does not yet exist at the Council Name. Risk Management Guidelines have been developed to support the City as it works towards a well defined approach.

The project examples discussed below provide significant lessons for the City, particularly, as the risk assessment and management processes adopted or lacking for each project is reviewed. A key part of this process will be to integrate a more participatory community consultation component into council requirements.

An overview of the Council Name current risk management approach for each water source follows.

Wastewater recycling

For wastewater recycling projects, the Council Name applies the risk management framework set out in these WSUD Guidelines.

Wastewater has a high inbuilt risk which needs careful risk management. This is known as an 'inherent' risk. Water recycling is closely regulated under the Environment Protection Act and is subject to works approvals, licensing provisions and septic tank provisions. Victorian requirements for works approvals and licensing are outlined in the frameworks for using reclaimed water and recycled water. There is limited regulation of small water recycling systems.

Victorian Government requirements for project governance and environmental and health risk management within water recycling schemes are provided in:

- EPA Publication 464.2: *Guidelines for Environmental Management: Use of Reclaimed Water*
- EPA Publication 1015: *Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes:*
  Health and Environmental Risk Management.

For the first time, the City has taken on responsibility for a water recycling project, through the water mining scheme at the City's offices at CH2. The key risk management approach for this scheme is based on EPA and DHS requirements, with all aspects of risk management managed inhouse. This will give the City first hand experience in documenting risk management processes – from selecting and installing treatment types to management and maintenance measures.

Stormwater recycling

For stormwater harvesting, the Council Name applies the risk management framework set out in these *WSUD Guidelines*.

Stormwater can be harvested and reused at local catchments. Increasingly local governments and developments are reusing harvested stormwater for open space irrigation.

Stormwater has a highly variable water quality due to local catchment variations. Draft guidelines for stormwater reuse for irrigation have been released by the EPHC – *Australian Guidelines for Water Recycling – Stormwater Harvesting and Reuse*, draft for public consultation, May 2008. This document provides guidance for:

- Roofwater reuse for larger buildings (greater than residential dwelling)
- Stormwater reuse for small to medium scale open space irrigation.

All other stormwater harvesting and reuse applications should take a risk-based approach.
These non-potable uses include:

- Toilet flushing
- Washing machine use
- Dust suppression
- Waterscape features (e.g. water fountains)
- Commercial food crop irrigation
- Home grown food irrigation
- Fire fighting, street cleaning
- Dual reticulation
- Industrial use.

The Royal Park Wetlands stormwater treatment and reuse scheme presents environmental and public health risk management concerns but as stormwater is unregulated it's not subject to legislative requirements. Council undertook a risk assessment prior to operationalising the scheme, and has conducted considerable monitoring of its performance since then with the assistance of Monash University's Engineering department. The findings of this monitoring will give the City the opportunity to develop a risk management approach specific to current and emerging risks observed in scheme performance, and will assist in the development of an appropriate risk management framework for such schemes into the future.

Bioretention tree pits installed on Little Bourke St have provided additional learnings. In partnership with Melbourne Water, the City delivered a detailed engagement and knowledge building program with traders in the area. This resulted in increased 'ownership' by Council of the responsibilities associated with managing risks that require community acceptance and enhanced knowledge of the expectations of users of water reuse schemes.

Rainwater

For rainwater harvesting, the Council Name applies the risk management framework set out in these *WSUD Guidelines*.

The first council rainwater harvesting project at Brens Pavilion did not incorporate a comprehensive risk management process due to its small scale nature and limited risks. However the newly operating scheme at Queen Victoria Market required significant risk management planning due to its ability to impact up to 10 million visitors a year. Water at Queen Victoria Market is harvested for toilet flushing, consequently the health risks associated with this use needed to be considered as part of this risk assessment.

Greywater

If managed carefully, domestic greywater used within the boundaries of a property where it is generated can become a low risk. It's important that appropriate treatment takes place, with:

- No cross connections
- Safe chemical management
- Appropriate end-uses such as underground garden and lawn watering, toilet flushing and clothes washing.

There are three types of greywater:

- Treated – where water is stored for more than 24 hours and requires treatment before reuse
- Diverted into plumbing – where water is diverted into plumbing fixtures for reuse within 24 hours
- Diverted with no plumbing – for example, running washing machine water directly onto gardens. No treatment or approvals are necessary for this diversion.

Treatment is required for uses that are medium risk:

- Laundry
- Surface irrigation
- Outdoor.

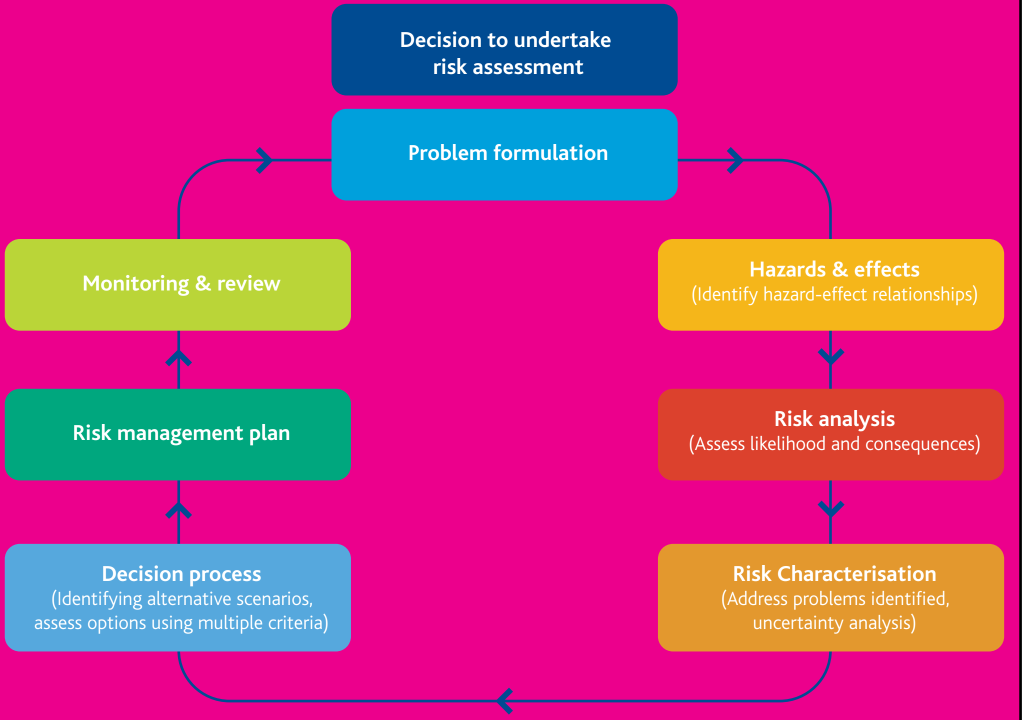
Insert information on how your Council is currently managing the risks of WSUD projects.

Risk management and governance procedures

Council recommends adopting the risk assessments framework shown in Figure 24 for any project. This assessment process is methodical and engages a range of stakeholders through a workshop format that can be separated into several key phases.

The model follows the PLAN, DO, CHECK, ACT model, supported by an Environmental Aspects and Impacts Register, standard risk assessment processes, and occupational health and safety requirements.

Figure 24. Risk analysis framework
(Hart, B. T. et al. (2005). Ecological Risk Management Framework for the Irrigation Industry, Water Studies Centre, Monash University, Melbourne, Australia, 55pp (www.wsc.monash.edu.au))



Risk assessments can range from a qualitative assessment to a quantitative analysis employing mathematical relationships. The level of complexity is determined by:

- Information available (or lack of)
- Resources assigned to each risk.

Each potential treatment option has different risks associated with:

- Technology
- Site constraints
- Potential identified uses.

These risks are based on the requirement that water reuse schemes achieve a 'fit-for-purpose' water quality standard.

Risk assessments are required for water recycling schemes. However there is no explicit requirement to cover an environmental or public health issue. You must identify any risk impacts and issues where there is a compliance requirement for Council works when submitting details of water recycling schemes for inclusion on Council's risk register.

Defining risk

The risk is defined as the likelihood (probability) of an adverse event multiplied by the consequence if that event occurs.

Risks can be categorised as either:

- Inherent – the risks associated with the project concept itself, or
- Residual – the risks associated with the project after risk management controls have been put in place.

Examples

- A dual pipe estate using reclaimed sewage can have high inherent risk but low residual risk due to the extensive risk management controls.
- In contrast, local greywater recycling may present a lower inherent risk, but due to the limited reliable end use controls, could represent unacceptable residual risks.

These guidelines focus on using good management to minimise inherent risk to an acceptable residual risk level. The guidelines don't relate to projects with very high inherent risks as Council believes such projects should not be considered.

Commitment to risk management

Council supports and promotes responsible implementation of water sensitive urban design projects.

It recognises the limitations of current legislation for alternative water use schemes and advocates management that meets the needs of all users and the environment.

In its role as scheme manager, scheme participant, approval authority and community leader, the Council will implement and promote the use of 'fit for purpose' water through:

- *Risk management*
- *Management procedures*
- *Communication*
- *Monitoring and reporting*.

Risk management includes:

- User-based, risk-oriented approach to the analysis of 'fit for purpose' water management options
- Preventative risk management approach and an appropriate water quality management system
- Contingency planning and incident response capability.

Management procedures include:

- Water quality management at relevant points along the delivery chain, from water source to point of application or recycled water user
- Processes and procedures to protect public and environmental health
- Planning processes that integrate the needs and expectations of water users, regulators, employees, other stakeholders and the environment
- Appropriate technical expertise in developing and managing water schemes
- Training to ensure all managers and employees involved in the supply of treated water can implement, maintain and continuously improve a recycled water scheme.

Communication includes:

- Partnerships with stakeholders involved in managing water recycling schemes
- Best practice community consultation, enabling participation in decision-making processes relating to the design, delivery and management of schemes.

Monitoring and reporting includes:

- Regular monitoring of control measures and water quality
- Effective reporting mechanisms to provide relevant and timely information
- Regular performance assessment to improve management practices and meet stakeholder expectations
- Mandatory reporting of non conformances with critical limits and routine reporting of operational data.

Risk Management Framework

This risk management process has been developed for all water recycling schemes operated by Council that collect and treat stormwater, rainwater, greywater and wastewater. Figure 25 shows the risk management framework for water recycling schemes in the IMAP area.

A range of fact sheets are proposed to help guide residents. However, the scope of this framework does not include water recycling schemes developed and managed by residents.

The framework has three key phases, each with defined tasks that must be completed. More detail about these key steps is provided below.

Phase 1: Assess project significance and level of risk (steps 1-2)

Phase 2: Conduct risk assessment (step 3)

Phase 3: Develop, apply and monitor risk management plan (steps 4-6).

Resources that will help develop a risk management approach to water recycling include fact sheets, a project management checklist and a risk management plan template.

A risk management plan should cover:

- Regulatory requirements
- Scheme design
- Installation and operational procedures
- Monitoring
- Corrective action
- Communication and engagement protocols.

It should ensure multiple barrier controls are applied where necessary. For example:

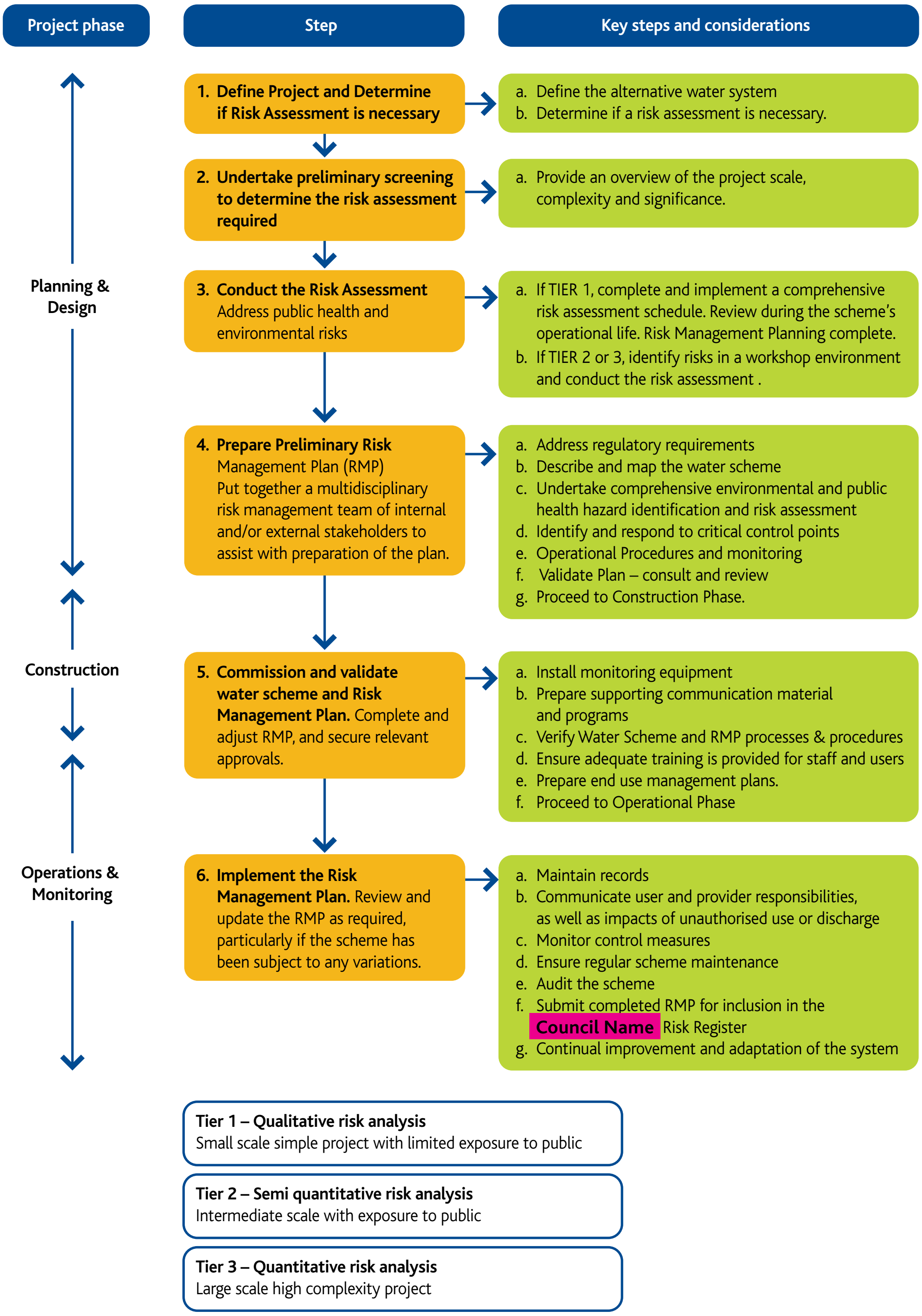
- Asset control mechanisms
- Education
- Technological barriers
- Plumbing and distribution controls
- Signage
- Operational procedures.

Corporate governance: compliance and liability management

The lack of an Environmental Management System (EMS) at some Councils limits the potential for appropriate water quality management within recycling schemes. Until an EMS is developed, risk management documentation must be integrated into each Council's corporate governance processes. At this stage, the most appropriate mechanism for legal compliance and liability management is to ensure a risk management plan is included on the relevant Council's risk register.

The best approach to managing potential liability issues is to design a system that minimises the risk of improper or unauthorised use of a treated (and untreated) product. Also consider product quality to address risks of improper use. Adhering to plumbing and other regulations, running awareness and education programs and ensuring an appropriate frequency of monitoring will help manage these issues.

Figure 25. Risk Management Framework for Water Recycling Schemes



1. Define Project and Determine if Risk Assessment is necessary

a. Define the alternative water system
b. Determine if a risk assessment is necessary.

2. Undertake preliminary screening to determine the risk assessment required

a. Provide an overview of the project scale, complexity and significance.

3. Conduct the Risk Assessment Address public health and environmental risks

a. If TIER 1, complete and implement a comprehensive risk assessment schedule. Review during the scheme's operational life. Risk Management Planning complete.
b. If TIER 2 or 3, identify risks in a workshop environment and conduct the risk assessment .

4. Prepare Preliminary Risk Management Plan (RMP) Put together a multidisciplinary risk management team of internal and/or external stakeholders to assist with preparation of the plan.

a. Address regulatory requirements
b. Describe and map the water scheme
c. Undertake comprehensive environmental and public health hazard identification and risk assessment
d. Identify and respond to critical control points
e. Operational Procedures and monitoring
f. Validate Plan – consult and review
g. Proceed to Construction Phase.

5. Commission and validate water scheme and Risk Management Plan. Complete and adjust RMP, and secure relevant approvals.

a. Install monitoring equipment
b. Prepare supporting communication material and programs
c. Verify Water Scheme and RMP processes & procedures
d. Ensure adequate training is provided for staff and users
e. Prepare end use management plans.
f. Proceed to Operational Phase

6. Implement the Risk Management Plan. Review and update the RMP as required, particularly if the scheme has been subject to any variations.

a. Maintain records
b. Communicate user and provider responsibilities, as well as impacts of unauthorised use or discharge
c. Monitor control measures
d. Ensure regular scheme maintenance
e. Audit the scheme
f. Submit completed RMP for inclusion in the **Council Name** Risk Register
g. Continual improvement and adaptation of the system

Tier 1 – Qualitative risk analysis
Small scale simple project with limited exposure to public

Tier 2 – Semi quantitative risk analysis
Intermediate scale with exposure to public

Tier 3 – Quantitative risk analysis
Large scale high complexity project

Part 2

Module 2.7

Site Design and Approvals

This module covers how water sensitive urban design (WSUD) can be integrated into the design and construction of different urban development sites, taking into account approvals and compliance issues. For technical design and construction issues, refer to the *WSUD Engineers Procedures: Stormwater Manual*[28].

Incorporating WSUD into urban layouts

Open space layout

There are many opportunities to use WSUD to improve open space, conservation corridors and recreational facilities. For example, stormwater could be treated as it flows through landscape features such as grassed swales and wetlands.

When locating open space areas, consider the following principles:

- Align open space along natural drainage lines
- Protect and enhance areas containing natural water features and other environmental values
- Use open space to link public and private areas and community activity nodes, especially in new developments.

Road layouts and streetscaping

Roads can significantly change the way water is transported because they create large areas of impervious hard surfaces in a typical urban development. When using WSUD stormwater harvesting techniques, roads are a great source of water.

Roads also generate waterborne stormwater contaminants that can damage the health of the receiving waterway. These include fine sediments, metals and hydrocarbons. Consequently, it's important to carefully plan road alignments and streetscapes to lessen the impact of stormwater runoff from road surfaces.

The continual upgrade of roads and streets provides opportunity to incorporate stormwater elements by diverting the flow from the road to a treatment system such as a raingarden or vegetated swale. To do this, traditional road features such as medians, traffic calming bays, street trees and car parking nodes must be slightly lowered below the road level to collect runoff from the road. Other features such as kerb and channel can be replaced with grass swales. Street trees can be retrofitted into stormwater treatment planter boxes.

Figure 26 shows how stormwater is filtered through a loamy sand before it's released to the stormwater systems.

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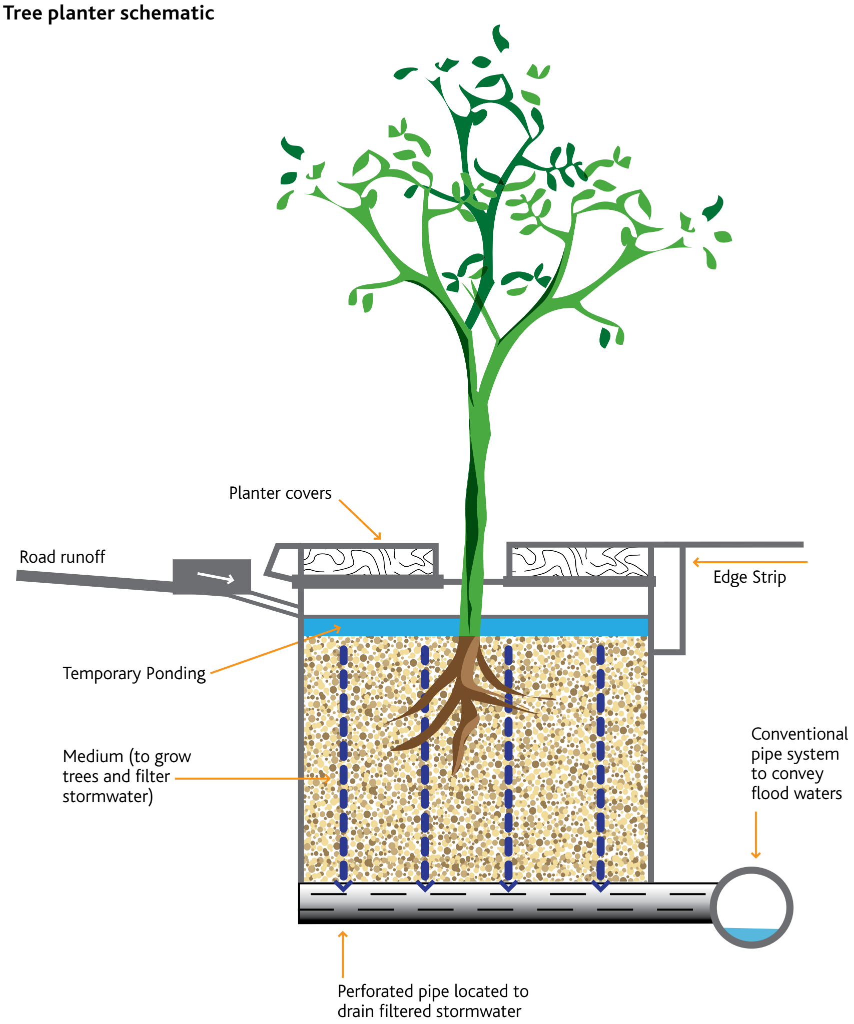
[28] WSUD Engineering Procedures: Stormwater, CISRO 2005

Figure 26. Tree planter schematic



Bioretention tree pits can be installed when street trees are planted. This means that trees are watered by the road runoff which is then filtered through sand before it's released into the stormwater systems. Figure 27 shows a series of street trees – bioretention & conventional.

Figure 27. Street planter boxes showing the construction of a planter, a modified tree planter and a traditional planter box.

Construction of a planter tree **Modified tree planter** **Traditional street tree**

Traffic medians, traffic treatment beds and roadways can be retrofitted to become raingarden systems. Examples include Little Bourke St, Melbourne and Cremorne St, Richmond where an urbanised street was retrofitted with raingardens.

Figure 28 below shows how the vegetated area (on the left) can be retrofitted to include a stormwater entrance. Stormwater overflow in high flow events is diverted directly to the side entry pit. The low flow, which is the majority of rainfall in Melbourne, and initial runoff (first flush) during storm events are treated by the raingarden. The majority of contaminants are contained in the low flow runoff and initial runoff in storm events.

Figure 28. Medians and vegetated road verges can be retrofitted to accept stormwater for treatment.

Lot layouts

The development of new lots has limited application to the inner areas of Melbourne. When it does apply, it's useful to integrate open space with WSUD elements.

WSUD promotes smaller, more compact housing lots adjacent to open space areas that typically have high amenity value. This allows greater community access to open space and WSUD elements. For example, natural and landscaped water features can form part of the local stormwater drainage and treatment system. Natural landscape features such as significant remnant vegetation and natural waterways should be incorporated into open space with housing lots wherever practical.

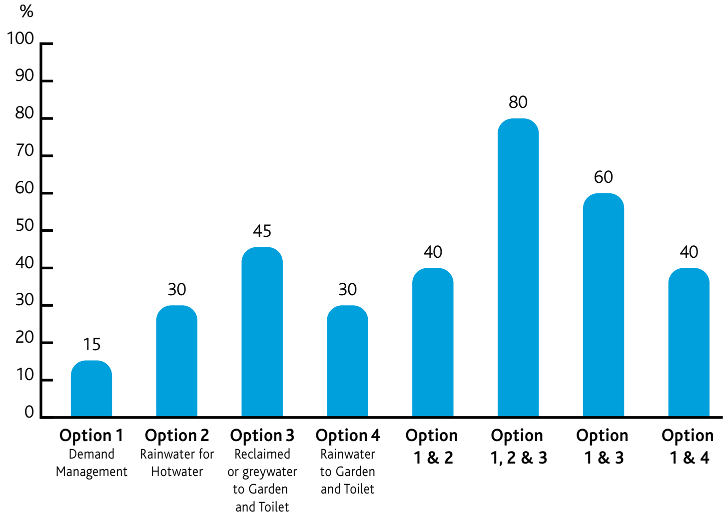
Application to development scales

Applying the three-step approach to selecting WSUD options (in Module 2.2), users have:

- Firstly, reduced demand for water
- Secondly, sourced alternate water for uses that do not require potable water (fit-for-purpose approach to water management)
- Thirdly, ensure stormwater is treated prior to it entering water bodies.

The potable water savings that can be achieved for different WSUD applications are outlined in Figure 29.

Figure 29. Expected potable mains savings from demand management and reuse options



The summaries below show how WSUD options can be used within different development scales.

Low density residential

Low density households can combine water efficiencies, rainwater harvesting and in some cases greywater technologies to reduce mains water demand. For typical suburban residential households, the expected potable mains water savings through demand management and water reuse options is shown in Figure 29.

The greatest potable mains water saving (80%) can be achieved through a combination of:

- Demand management (option 1)
- Rainwater for hot water (option 2)
- Recycled water or greywater for toilet flushing and garden irrigation (option 3).

In the absence of recycled water (e.g. water mining or greywater systems), a 40% saving can be achieved through a combination of:

- Demand management (option 1)
- Rainwater used for toilet flushing and garden watering (option 4).

A case-by-case approach to achieving water demand reductions will take into account:

- Development scale
- Layout
- Proximity to wastewater treatment facilities
- Local climate
- Willingness to manage any recycled water systems.

High rise residential development

High rise urban development is typical of present and future residential growth within inner Melbourne. In high rise apartments, residential water demand is similar to a typical household with the exclusion of garden irrigation. The base buildings require the efficiencies of centralised hot water systems. Stormwater capture from the roof (and possible carpark/plaza/garden area) will reduce stormwater pollution. However the relatively small ratio of surface area to water demand (i.e. number of people) limits this as alternative water source.

Therefore the preferred combination for high rise residential development is:

- Demand management (option 1)
- Reclaimed or greywater for toilet use (option 3).

Commercial office development

Toilet flushing is typically the main use of water in office buildings. Relatively small demand exists for drinking water, bathrooms and garden irrigation. Shower use is low, so little greywater generation can be expected. Stormwater capture from the roof (and possible carpark/plaza/garden area) will reduce stormwater pollution. However the relatively small ratio of surface area to water demand (i.e. number of people) limits this as alternative water source.

Therefore the preferred combination for commercial office development is:

- Demand management (option 1)
- Reclaimed water for toilet flushing (variation of option 3 involving sewer mining).

Demand management will result in significant savings in water bills for the office buildings. However installing sewer mining systems is costly, so ideally this facility should be shared amongst adjacent buildings.

Events and institutions development

The commercial sector also includes schools, universities, hospitals, markets and event venues. These venues can reduce water demand through efficient toilets, showers, appliances and fittings including fire sprinkler systems and cooling towers (option 1).

Buildings with large catchment areas (e.g. roof areas) can harvest rainwater and use for toilet flushing and irrigation (option 2) as such venues often have large gardens (option 3). Stormwater can also be harvested from large car park and garden areas to provide water quality improvement.

Mixed use urban development

Residential and commercial uses are typically combined in a mixed use development. Building height, density, landscape area and use will determine the WSUD strategy.

The feasibility of rainwater harvesting will be determined by the ratio of stormwater roof runoff to the number of residents. Similarly, the amount of stormwater harvesting will be determined by the ratio of plaza, carpark and open space area. Greywater can usually be collected to provide an alternative water source.

Therefore the preferred combination for mixed use urban development is:

- Demand management (option 1)
- Recycled water or greywater for toilet flushing and garden irrigation (option 3).

Industrial development

Industrial water use is dependent on the specific industry and site. Usage ranges from cooling water for industrial equipment to very high purity water for technology companies. Industry should use ‘fit-for-purpose’ water and be able to demonstrate best water management and practice.

Industrial sites often have large roof spaces and car parks, offering valuable opportunities for rainwater and stormwater harvesting. For example:

- Multiple uses of water within a manufacturing site
- Reclaimed water for process cooling applications
- Stormwater harvesting for onsite use.

As industrial developments and their water use are varied throughout the Council Name, approaches should be developed on a case-by-case basis.

The combination of appropriate water sensitive urban designs are further developed in the Case Studies in Part 3 of these guidelines.

Modelling stormwater performance

Stormwater quality improvement systems in urban areas are predominantly driven by climatic factors such as the occurrences of storm events and dry weather conditions. These factors are highly variable in terms of the seasonality of the occurrences of storm events, their magnitudes and durations.

The performance of an urban stormwater quality improvement strategy is determined over a continuous period of typical climatic conditions, rather than an individual storm event. Monitoring and water quality sampling of a small number of storm events are normally not sufficient to define system performance.

Using well-established computer models of urban stormwater management systems is a recognised method to determine long-term performance. Modelling involves the use of historical or synthesized long-term rainfall data that can simulate the performance of stormwater treatment measures to determine stormwater pollution control outcomes.

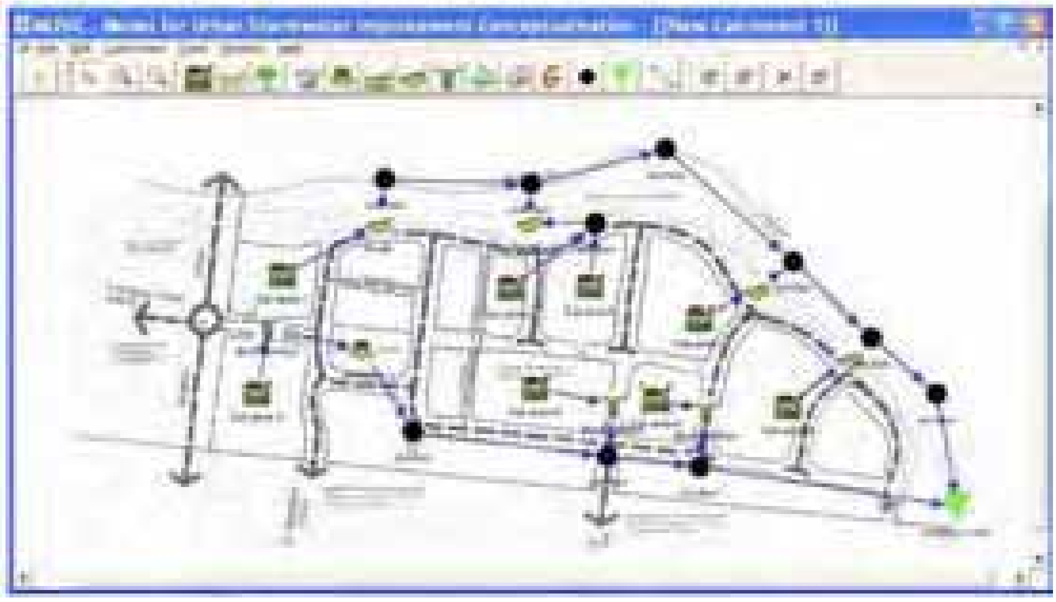
Modelling is required for WSUD solutions on sites larger than single households.

MUSIC modelling

The Cooperative Research Centre for Catchment Hydrology (now eWater) has developed stormwater management evaluation software called MUSIC[29].

The software provides a planning and decision support system. Through an easy-to-use tool, it presents the most current knowledge of the performance of a range of stormwater treatment measures. MUSIC is designed to operate at a range of temporal and spatial scales, suitable for modelling stormwater quality treatment systems from individual lots up to regional scales.

Figure 30. The structure of a MUSIC model to evaluate stormwater treatments using rain gardens in a typical residential development



Using MUSIC, you can make a first estimate on the expected pollutant load from catchments following development, in the absence of any stormwater treatment initiatives. This sets a baseline condition which can then be used to compare alternative stormwater treatment strategies for compliance with state and local government stormwater quality objectives.

Figure 30 shows an example of a MUSIC model, representing the evaluation of stormwater treatments for a typical residential development.

STORM modelling tool

The STORM tool is a simple modelling tool for small scale development. It's based on achieving best practice for a particular site. This is a simplified version of the MUSIC tool to be used for non-complex developments.

The STORM tool is available from Melbourne Water's website and is easily accessible for local governments, households and developers (www.storm.melbournewater.com.au).

Other modelling approaches

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 an overall 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.

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[29] For more details – www.catchment.crc.org.au

Approvals and compliance

Stormwater

Stormwater treatment works can take various forms in the urban environment. Some treatment works will involve:

- Infrastructure upgrades
- Streetscape layout changes
- Piping reconfigurations
- Storage tanks
- Laying of different paving and other such variations.

In many of these cases, planning approval will be necessary.

Applications for planning approval are required where there will be changes to land use and/or development works that impact the local environment. Meet with the statutory planning department of Council as soon as possible to determine whether a permit is needed for your proposed work. Also seek advice about the information that needs to be submitted and the likely timing of the approval.

Heritage provisions apply to most of the Council Name and therefore a heritage permit may also be needed.

Clause 56 for residential sub-divisions

Clause 56 of the State Planning Policy was modified in October 2006 which requires all new residential subdivisions to incorporate integrated water management. The urban run-off management objectives 56.07-4 address urban stormwater.

Like these *WSUD Guidelines*, the standards to be met under Clause 56 include performance objectives set out in the *Urban Stormwater Best Practice Environmental Management Guidelines* (BPEMs), published by CSIRO in 1999, as amended.

Incorporating water sensitive urban design (WSUD) elements as part of the drainage system is one of the main ways to meet these standards. The development industry and local government officers therefore need to understand:

- What are the principles behind WSUD?
- What are the various technologies that can be used?
- What is the best technology or device for a particular situation?
- How to use industry design and assessment tools to determine whether a particular suite of technologies will meet the BPEM objectives

New site management provisions are set out in the Site Management Objectives 56.08-1. These provisions require that subdivision applications describe how the site will be managed to minimise environmental impacts.

Greywater

Simple greywater diversion systems that do not store greywater for more than 24 hours do not require approval.

EPA Victoria approval is required for greywater treatment systems that treat more than 5000L/day. Contact EPA Victoria directly for more information about the approval process.

Larger scale treatment systems have a more stringent water quality standard, as they are more likely to include sewage/blackwater inputs. These systems require a water quality standard of Class A to be met. Refer to table 5 in Module 2.2 or, for more detail, to EPA Publications 464.2, Use of Reclaimed Water and 1015, Dual pipe water recycling schemes – health and environmental risk management).

For systems treating less than 5000L/day, EPA approval is not required for a closed system (when no water is released to the environment). A council permit must still be obtained and an EPA approved systems system must be used. Required water quality standards and appropriate uses are listed in table 2 in Module 2.2. More information can be obtained from EPA Publication 891.2: Code of Practice: Onsite Wastewater Management.

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. The Green Plumbers (*www.greenplumbers.com.au*) and the Plumbing Industry Commission (*www.pic.vic.gov.au*) websites have additional information.

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

Recycled water (sewage/blackwater)

EPA Victoria approval is required for water treatment systems treat more than 5000L/day. Contact EPA Victoria directly for more information about the approval process.

EPA Victoria has guidelines for the production and use of recycled water from sewage treatment plants (refer to publications 1015 and 464.2). Use these guidelines to assess requirements for large scale water treatment.

Treatment and water quality standards is required to be consistent with recycled water from meet Victoria's guidelines for reclaimed water. Refer to table 2 in Module 2.2 or, for more detail, to EPA Publications 464.2, Use of Reclaimed Water and 1015, Dual pipe water recycling schemes – health and environmental risk management).

Sewage/blackwater recycling systems treating less than 5000L/day require slightly less stringent approval (EPA Certificate of Approval) and quality standards (20/30/10 standard) than larger systems. Such treatment systems fall under the EPA Publication 891.2: *Code of Practice: Onsite Wastewater Management*.

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. The Green Plumbers (*www.greenplumbers.com.au*) and the Plumbing Industry Commission (*www.pic.vic.gov.au*) websites have additional information.

The Department of Health has responsibility for approving large scale reclaimed water systems where there is a potential for 'high exposure' from Class A water applications. High exposure examples 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/*).

Part 2

Module 2.8

Maintaining WSUD Assets

This module summarises the issues relating to the operation and maintenance of water sensitive urban design (WSUD) projects[34].

Key aspects of maintenance

The condition of the civil works and the landscape will impact on maintenance needs of a WSUD system. Civil works generally require minimal maintenance apart from checks to ensure drainage function[30]. Landscape areas require ongoing maintenance to maintain vegetation and plant health, control weeds, remove litter and sediment and maintain design levels and the efficiency of the treatment system in removing pollutants.

Maintenance activities need to ensure officer safety and should not require direct contact with pollutants and other trapped materials. Common maintenance activities across many WSUD systems include:

- Horticultural (weed control and pruning) activities to maintain health of plantings
- Removing litter and debris
- Replanting vegetation (if garden bed style system)
- Mowing grass if turf present (typically in swales)
- Managing algae
- Preventing root growth into drainage pipes
- Draining to avoid blockages, ponding or unnecessary bypassing from sediment build up
- Cleaning and renewing the filter media surface to maintain treatment efficiency
- Visual checks after rainfall to check infiltration is at optimum efficiency
- Disposing of solid wastes
- Maintaining pumps.

Appendices 2 - 8 detail the specific maintenance requirements for different WSUD systems.

Maintenance over the life of a project

Across the life of a project, the level of maintenance varies. In the two years immediately following construction (the establishment period), more maintenance takes place. During this period, weed removal and replanting may be needed, in particular for catchments with poor building controls. Monitoring should be more frequent when construction is occurring in the catchment, as sedimentation may also be a problem and can affect the functioning of WSUD systems.

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[30] Information sources include:
- Somes and Crosby (2006) report [34] (rain gardens)
- WSUD Engineering Procedures: Stormwater manual[34] (other WSUD systems)
- Water Sensitive Urban Design Technical Design Guidelines for South East Queensland[34] (other WSUD systems).

Maintenance plans

All maintenance activities must be specified in a maintenance plan and associated maintenance inspection forms. These are developed as part of the design process. Maintenance personnel and asset managers use this plan to make sure that the WSUD system continues to function as it was designed.

Maintenance plans and forms must address the following:

- Inspection frequency
- Maintenance task frequency
- Data collection/ storage requirements (i.e. during inspections)
- Detailed cleanout procedures (main element of the plans) including:
  - equipment needs
  - maintenance techniques
  - occupational health and safety
  - public safety
  - environmental management considerations
  - disposal requirements (of material removed)
  - access issues
  - stakeholder notification requirements
  - data collection requirements (if any)
- Design details, including a description and sketch of how the system operates.

Use maintenance checklists whenever an inspection is conducted and keep them as a record on the asset condition and quantity of removed pollutants over time. Generally, inspection frequencies are every three to six months for Victoria. Appendices 2 - 8 contain examples of WSUD maintenance checklists.

Rain gardens maintenance

The information in the Somes and Crosby (2006) case study is based on a recent review of 22 water sensitive urban design (WSUD) street scale projects.

Post construction maintenance

Immediately after a rain garden is built, there is an important period where the landscape system is established. During this time, a range of works are needed, including:

- Watering – as required
- Control of weeds – a monthly visit
- Removal of litter and sediment – as required
- Replacement of plant losses – typically 10% to 15% of initial plantings.

These costs are typically the responsibility of the contractor. They will be between 10% and 25% of the soft landscape (planting and mulching works) construction cost per annum. Small sites often involve significant mobilisation, therefore higher establishment costs.

A two year post construction maintenance period is generally recommended before handing assets over to Council on large projects. For smaller projects, a shorter maintenance period may be appropriate if Council has the resources to undertake maintenance.

The cost of maintenance is less if Council takes over the site after an initial six month maintenance period, as the landscape can be maintained using local resources with no additional travel costs. Commercial landscapers also have to make assumptions about the proportion of re-plants, watering and weed control. Therefore cost estimates provided by contractors for maintenance during the establishment phase generally include contingencies, as contractors need to recover costs for all works undertaken.

Long term maintenance

To ensure the ongoing aesthetics and function of rain gardens, long term maintenance is needed. Maintenance activities are divided into the following key areas:

- Aesthetics
- Horticulture
- Damage
- Inspections.

Maintenance frequencies for rain gardens

Use the different maintenance categories in Table 12 to gain an understanding of the estimated maintenance cost for rain garden sites. The ranges in frequency of maintenance reflect the site review findings for typical urban and industrial areas. It's important to note that in some cases a significantly higher frequency of visits will be needed due to the nature of the site, i.e. a high visitation local park.

Table 12. Recommended maintenance actions and frequencies for rain gardens
(adapted from Somes and Crosby 2006)

Action	Frequency
Asthetics	
Litter and organics removal	As required. Typical range 12-18 visits per year.
Sediment removal	As required. Only expected if there was a new sediment source present in catchment, e.g. construction works.
Vegetation	
Weed control	6 to 12 visits per year.
Replanting	5% per year after the first two years of maintenance.
Mulching	Top up annually if required.
Damage	Repair accidental and deliberate damage as required.
Inspections	
Functional elements	Every 5 to 10 years an inspection of drainage elements is undertaken.
Landscape	Every 5 to 10 years an inspection of the landscape is undertaken.
Infiltration	Every 5 to 10 years an in situ infiltration test should be undertaken.

A well functioning rain garden has similar maintenance needs as other gardens beds. Therefore many new rain garden areas have been assimilated into Councils' maintenance regimes across Melbourne. It's recommended that any estimate of future landscape maintenance cost be based on current maintenance costs for similar landscapes within the municipality[31].

Issues identified from metropolitan Melbourne site inspections

In metropolitan Melbourne, civil works and maintenance (weed and litter control) for WSUD projects are generally implemented well[35]. However some maintenance issues were identified, including the use of inappropriate mulches and loss of extended detention storage due to overfilling of filters.

Poor filter function was the most common issue identified in site inspections. Many filters had infiltration rates below that specified in the design. The results indicated that most WSUD measures had infiltration rates of less than 80 mm/hr, when the rate should be 100 - 300 mm/hr. Systems with low infiltration rates achieve lower than intended pollutant removal rates as systems bypass more frequently.

The low hydraulic conductivity of the filters was due to inappropriate selection of filter materials, in particular topsoil material was used in many rain gardens. Topsoil has a proportion of fine grade materials that is too high for this application. The fine materials clog soil pores and reduce the infiltrative capacity of the soil. Instead, turf sand (loamy sand) should be used as per Melbourne Water and FAWB specifications.

Plant growth was variable across the sites. Whilst poor plant growth due to waterlogged soils is not an ideal outcome, it does at least help staff to identify a potential filter function problem. Terrestrial plants (e.g. Dianella species) are better at showing low infiltration rates than semi-aquatic plants that can remain healthy in waterlogged soils. Where possible, use plants which prefer well drained conditions as they will indicate poor filter function.

No plants were found to be suffering stress from a lack of water despite the drought conditions during the study. This indicates that stormwater runoff to rain gardens contributes to their long term health.

Maintenance costs

Actual costs incurred by operators of WSUD systems have only recently become available and are listed in Appendix 1. These were collected by EPA Victoria[31] and generated from information available around Australia. Data is very limited for some measures such as buffer strips, rain gardens and infiltration systems.

The WSUD datasets are small and there is a large variation between systems. Therefore the figures should only be used as a useful check at the design stage.

Maintenance issues for water recycling systems

Rainwater and stormwater tanks

When the design has carefully considered the quality of the water entering the system, rainwater and stormwater tanks only need minimal maintenance. Harvested water must be as free as possible of debris, litter and sediment. For rainwater tanks this can be as simple as gutter guards, leaf diverter and/or first flush diverters. Maintenance tasks include the following:

- Inspect gutter guards, leaf diverter and/or first flush diverters every six months and clean if necessary
- Monitor sediment build-up within the tank every one to two years
- De-sludge every five years, if necessary.

Stormwater harvesting from roads and paved surfaces will need greater screening and treatment. These treatment measures may involve rain gardens, swales or gross pollutant traps. As most stormwater harvesting systems are large, they are often underground and therefore cleaning measures are limited. Pre-treatment is therefore more important than in systems which only use roof run-off (rainwater).

Greywater systems

Each greywater treatment will have its own maintenance requirements. Manufacturers and suppliers can provide relevant maintenance regimes. For example, a subsurface wetland will require minimal maintenance if adequate prefiltering and settling occurs before the filter bed. To ensure consistent flow, regularly clean and remove solids from the filters and screens.

Factor in adequate provision for downtime, such as scheduled maintenance. Therefore, connect the greywater plumbing to the mains and the sewer to:

- Enable immediate diversion and greywater disposal
- Provide for potable mains water to be temporarily used for toilet flushing.

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[31] EPA (2008) *Maintaining water sensitive urban design elements*, publication 1226

Blackwater systems

All water mining systems need regular maintenance. Technology selection will determine the maintenance management schedule. For example, membrane filtration processes will require regular membrane cleaning either chemically or physically with eventual membrane replacement.

Variable wastewater quality can affect operation and potentially harm the system, for example a peak caustic load in the sewer from an industrial customer. Regulatory approaches have minimised these occurrences, using license agreements to stipulate pollutant loading and advanced approaches to track 'rogue' customers.

Maintaining pumps

Undertake maintenance on pumps for the storage and distribution of water and wastewater in WSUD systems as part of a scheduled maintenance program.

Most pump maintenance activities centre on:

- Checking packing and mechanical seals for leakage
- Peforming preventive or predictive maintenance activities on bearings
- Assuring proper alignment
- Validating proper motor condition and function.

Table 13 below shows a generic pump maintenance checklist. However it's always good practice to check with manufacturers and suppliers for the relevant maintenance regimes.

Table 13. Generic pump maintenance checklist

		Maintenance frequency		
Description	Action	Every 3 mths	Every 6 mths	Annually
Pump use and sequencing	Turn off or sequence unnecessary motors.	•		
Overall visual inspection	Complete overall visual inspection to check all equipment is operating and safety systems are in place.	•		
Check lubrication	Make sure that all bearings are lubricated per the manufacturer's recommendation.		•	
Check packing	Check packing for wear and repack as necessary.		•	
	Consider replacing packing with mechanical seals.		•	
Motor and pump alignment	Align the pump/motor coupling to allow for efficient torque transfer to the pump.		•	
Check mountings	Check and secure all pump mountings.		•	
Check bearings	Inspect bearings and drive belts for wear.			•
	Adjust, repair or replace as necessary.			•
Motor condition	Check the condition of the motor through temperature or vibration analysis to assure long life.			•

(Adapted from U.S. Department of Energy - Energy Efficiency and Renewable Energy Federal Energy Management Program)
www1.eere.energy.gov/femp/operations_maintenance

Appendix 1 – Maintenance costs for rain gardens and other treatment devices

Rain garden street-scale works to date have shown that maintenance costs average between $3.80 and $20 per square metre of landscape per annum[32]. The range of costs reflects the profile of the site to be maintained, with higher profile sites requiring greater maintenance intervention.

Table 14 shows a typical maintenance regime. Two maintenance regimes were developed and costed, reflecting the profile of various sites. Annual costs are:

- $8.76/m^2 for low maintenance levels
- $13.25/m^2 for high maintenance levels.

Annual inspections and litter pick up take up a large proportion of the maintenance costs. If you want to reduce maintenance inputs, make savings in these areas, rather than reducing weed control or replanting. Coordinate maintenance of rain gardens with adjacent landscapes to reduce the costs.

Table 14. Estimated annual maintenance costs per square meter of rain garden

Activities	Lower cost	Upper cost
Aesthetics	$ 4.80	$ 7.20
Vegetation	$ 3.00	$ 4.13
Damage	$ 0.96	$ 1.92
Total annual cost	**$ 8.76**	**$ 13.25**

Source: Somes and Crosby 2006

Table 15. Typical maintenance costs for various WSUD systems, EPA 2008

Treatment devices	Typical annual maintenance cost (TAM)	Correlation
Constructed wetlands	TAM ($2004) = 6.831 x (A) 0.6435	R2= 0.76; p< 0.01; n= 21
Vegetated swales	TAM ($2004) = 48.87 x (TAC) 0.4407	R2= 0.94; p= 0.03; n= 4
Buffer strips	TAM ($2004) = 48.87 x (TAC) 0.4410	R2= 0.94; p= 0.03; n= 4
Rain gardens	TAM ($2004) = 48.87 x (TAC) 0.4410	R2= 0.94; p= 0.03; n= 4
Ponds and sediment basins	TAM ($2004) = 185.4 x (A) 0.4780	R2= 0.92; p= 0.04; n= 4
Infiltration systems	TAM ($2004) = 30.15 x (TAC) 0.4741	R2= 0.80; p= 0.04; n= 5

Source: EPA Maintaining water sensitive urban design elements, publication 1226

Notes

The size/cost relationships for TAM, TAC and RC are derived from a combined data set involving vegetated swales, buffer strips and rain gardens. There is insufficient data to analyse swales on their own.

A = surface area of treatment zone/ basin/ infiltration system in m^2.

TAC = total acquisition cost.

R2 = explanation of variance

p = significance

n = number of samples p is derived from.

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[32] Somes and Crosby (2006) report

Appendix 2 – Maintenance requirements for swales (incorporating buffer strips)

Swale treatment relies upon good establishment of vegetation. Therefore ensuring adequate vegetation growth is the key maintenance objective. Swales also have a flood conveyance role that needs to be maintained to protect local properties from flood.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

Carefully monitor the potential for rilling and erosion along a swale, particularly during establishment stages of the system. The inlet points (if the system does not have distributed inflows) and surcharge pits will also need careful consideration. The inlets can be prone to scour and build up of litter and sediment.

Swale field inlet pits also require routine inspections to check structural integrity and blockages with debris.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of swale elements will involve:

- Routinely inspecting the swale profile to identify any:
  - areas of obvious increased sediment deposition
  - scouring of the swale invert from storm flows
  - rill erosion of the swale batters from lateral inflows
  - damage to the swale profile from vehicles
- Routinely inspecting inlet points (if the swale does not have distributed inflows), surcharge pits and field inlet pits to identify any:
  - areas of scour
  - litter build up
  - blockages
- Removing sediment where it is impeding the conveyance of the swale and/ or smothering the swale vegetation and if necessary reprofiling of the swale and revegetating to original design specification
- Repairing damage to the swale profile resulting from:
  - scour
  - rill erosion
  - vehicle damage
- Clearing blockages to inlet or outlets
- Regular watering/ irrigation of vegetation until plants are established and actively growing
- Mowing turf or slashing vegetation (if required) to preserve the optimal design height for the vegetation
- Removing and managing invasive weeds
- Removing plants that have died (from any cause) and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and stimulate new growth
- Removing litter and debris
- Monitoring and controlling vegetation pests.

Swale and Buffer Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within swale?		
Erosion at inlet or other key structures (e.g. crossovers)?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Mowing required?		
Sediment accumulation at outlets?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Set down from kerb still present?		
Soil additives or amendments required?		
Pruning and/ or removal of dead or diseased vegetation required?		

Comments

Appendix 3 – Maintenance requirements for bioretention swales

The flood conveyance role of bioretention swales must be maintained to ensure adequate flood protection for local properties. Vegetation plays a key role in maintaining the porosity of the sand of the bioretention system. Strong healthy growth of vegetation is critical to its performance.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

Carefully monitor the potential for rilling and erosion along a swale, particularly during establishment stages of the system. The inlet points (if the system does not have distributed inflows) and surcharge pits will also need careful consideration. The inlets can be prone to scour and build up of litter and sediment.

Bioretention swale field inlet pits also require routine inspections to check structural integrity and blockages with debris.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of bioretention swale elements will involve:

- Routinely inspecting the swale profile to identify any:
  - areas of obvious increased sediment deposition
  - scouring of the swale invert from storm flows
  - rill erosion of the swale batters from lateral inflows
  - damage to the swale profile from vehicles
  - clogging of the bioretention trench (evident by a 'boggy' swale invert)
- Routinely inspecting inlet points (if the swale does not have distributed inflows), surcharge pits and field inlet pits to identify any:
  - areas of scour
  - litter build up
  - blockages
- Removing sediment where it's impeding the conveyance of the swale and/ or smothering the swale vegetation, and if necessary, reprofiling of the swale and revegetating to original design specification
- Repairing damage to the swale profile resulting from:
  - scour
  - rill erosion
  - vehicle damage
- Tilling the bioretention trench surface if there is evidence of clogging
- Clearing blockages to inlet or outlets
- Regular watering/ irrigation of vegetation until plants are established and actively growing
- Mowing turf or slashing vegetation (if required) to preserve the optimal design height for the vegetation
- Removing and managing of invasive weeds
- Removing plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and to stimulate new growth
- Removing litter and debris
- Monitoring and controlling vegetation pests.

Resetting, or complete reconstruction, of bioretention elements will be required if the:

- Available flow area of the overlying swale is reduced by 25% (due to accumulation of sediment)
- Bioretention trench fails to drain adequately after tilling of the surface.

Inspections are also recommended following large storm events to check for scour.

Bioretention Swales Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within swale?		
Erosion at inlet or other key structures (e.g. crossovers)?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Mowing required?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Set down from kerb still present?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		
Remulching of trees and shrubs required?		
Soil additives or amendments required?		
Pruning and/ or removal of dead or diseased vegetation required?		
Resetting of system required?		

Comments

Appendix 4 – Maintenance requirements for sediment basins

Sediment basins treat runoff by slowing flow velocities and promoting settlement of coarse to medium sized sediments. Maintenance revolves around:

- Ensuring inlet erosion protection is operating as designed
- Monitoring sediment accumulation
- Ensuring that the outlet is not blocked with debris.

Outlets from sedimentation basins should be designed so that access to the outlet does not require a water vessel. Maintenance of the littoral vegetation including watering and weeding is also required, particularly during the first two years or the plant establishment period.

Inspect the inlet configuration following storm events soon after construction to check for erosion. Regular checks of sediment build up will also be needed as sediment loads from developing catchments vary significantly. The basins must be cleaned out if they are more than half full of accumulated sediment.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of sedimentation basins will involve:

- Routinely inspecting the sedimentation basin to identify:
  - depth of sediment accumulation
  - damage to vegetation
  - scouring or litter
  - debris build up (after first 3 significant storm events and then at least every 6 months)
- Routinely inspecting inlet and outlet points to identify any:
  - areas of scour
  - litter build up
  - blockages
- Removing litter and debris
- Removing and managing invasive weeds (both terrestrial and aquatic)
- Periodic draining and desilting (usually every 5 years) – this will require excavation and dewatering of removed sediment and disposal to an approved location
- Regular watering of littoral vegetation during plant establishment
- Replacing plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule.

Sediment Basins Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Litter accumulation?		
Sediment accumulation at inflow points?		
Sediment requires removal (record depth, remove if >50%)?		
All structures in satisfactory condition (pits, pipes, ramps etc.)?		
Evidence of dumping (building waste, oils etc.)?		
Littoral vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Weeds require removal from within basin?		
Settling or erosion of bunds/batters present?		
Damage/vandalism to structures present?		
Outlet structure free of debris?		
Maintenance drain operational (check)?		
Resetting of system required?		

Comments

Appendix 5 – Maintenance requirements for bioretention basins, rain gardens and WSUD treepits

Vegetation plays a key role in maintaining the porosity of the filter media of a bioretention system. A strong healthy growth of vegetation is critical to its performance.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Watering may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Where sediment forebays are adopted, regular inspection of the forebay is required. Remove accumulated sediment as required.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

For larger bioretention basins, it's essential to design and maintain a maintenance access point in the bioretention basin. The design will be guided by the size and complexity of the system and may involve provision of a reinforced concrete ramp/ pad for truck or machinery access.

Routinely inspect the bioretention basin profile to identify any:

- Areas of obvious increased sediment deposition
- Scouring from storm flows
- Rill erosion of the batters from lateral inflows
- Damage to the profile from vehicles
- Clogging of the bioretention basin (evident by a 'boggy' filter media surface).

Typical maintenance will involve:

- Routinely inspecting inflows systems, overflow pits and under-drains to identify and clean any:
  - areas of scour
  - litter build up
  - blockages
- Removing sediment where it is smothering vegetation
- Removing accumulated sediment where a sediment forebay is adopted
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match the design media) and revegetating
- Tilling of the surface, or removal of the surface layer, if there is evidence of clogging
- Regular watering/irrigation of vegetation until plants are established and actively growing
- Removing and managing invasive weeds (herbicides should not be used)
- Removing plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and to stimulate growth
- Monitoring and controlling vegetation pests.

Resetting (i.e. complete reconstruction) of the bioretention system will be required if it fails to drain adequately after tilling of the surface.

Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

Bioretention Systems Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within system?		
Erosion at inlet or other key structures?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Watering of vegetation required?		
Replanting required?		
Mowing/slashing required?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		
Resetting of system required?		

Comments

Appendix 6 – Maintenance requirements for constructed wetlands

Wetlands treat runoff by filtering it through vegetation and providing extended detention to allow sedimentation to occur. In addition, they have a flow management role that needs to be maintained to ensure adequate flood protection for local properties and protection of the wetland ecosystem.

Maintaining healthy vegetation and adequate flow conditions in a wetland are the key maintenance considerations. The main tasks are:

- Weeding
- Planting
- Mowing
- Removing debris.

The inlet zone needs to be maintained in the same way as sedimentation basins. Routine maintenance of wetlands should be carried out once a month.

The plant establishment period, during the first two years, is the most intensive period of maintenance.
This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments could impact on plant growth, particularly in developing catchments with poor building controls.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of constructed wetlands will involve:

- Desilting the inlet zone following the construction/ building period
- Routinely inspecting the wetland to identify any damage to vegetation, scouring, formation of isolated pools, litter and debris build up
- Routinely inspecting the inlet and outlet points to identify any areas of scour, litter build up and blockages
- Removing litter and debris
- Removing and managing invasive weeds
- Repairing the wetland profile to prevent the formation of isolated pools periodicly (usually every 5 years)
- Draining and desilting of the inlet pond every 2 to 5 years
- Regular watering of littoral vegetation during plant establishment
- Controlling the water level during plant establishment
- Replacing plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule
- Monitoring and controlling vegetation pests.

Inspections are recommended following large storm events to check for scour and damage.

Bioretention Basins Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within inlet or macrophyte zones?		
Sediment within inlet zone requires removal (record depth, remove if >50%)?		
Overflow structure integrity satisfactory?		
Evidence of dumping (building waste, oils etc.)?		
Terrestrial vegetation condition satisfactory (density, weeds etc.)?		
Aquatic vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Settling or erosion of bunds/batters present?		
Evidence of isolated shallow ponding?		
Damage/vandalism to structures present?		
Outlet structure free of debris?		
Maintenance drain operational (check)?		
Resetting of system required?		

Comments

Appendix 7 – Maintenance requirements for infiltration

Maintenance for infiltration measures aims to:

- Stop the system clogging with sediments
- Keep the appropriate infiltration rate.

The most important consideration during maintenance is to ensure the pre-treatment elements are operating as designed to:

- Avoid blockage of the infiltration measure
- Prevent groundwater contamination.

The infiltration zone should be inspected every 3-6 months (or after each major rainfall event) to ensure the system is operating as designed. Frequency will depend on the size and complexity of the system.

Typical maintenance of infiltration systems will involve:

- Routinely inspecting the system to identify any surface ponding after the design infiltration period, which would indicate clogging/blockage of the underlying aggregate or the base of the trench
- Routinely inspecting inlet points to identify any areas of scour, litter build up, sediment accumulation or blockages
- Removing of accumulated sediment and clearing of blockages to inlets
- Tilling of the infiltration surface, or removing the surface layer (if there is evidence of clogging)
- Maintaining the surface vegetation (if present).

Infiltration Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation in pre-treatment zone?		
Erosion at inlet or other key structures?		
Evidence of dumping (e.g. building waste)?		
Evidence of extended ponding times (e.g. algal growth)?		
Evidence of silt and clogging within 'detention volume'?		
Clogging of flow management systems (sediment or debris)?		
Damage/vandalism to structures present?		
Drainage system inspected?		
Resetting of system required?		

Comments

Appendix 8 – Maintenance requirements for sand filters

Sand filter maintenance mainly concerns:

- Regular inspections (3-6 monthly) to inspect the sedimentation chamber and the sand filter media surface, in particular immediately after construction
- Checking for blockage and clogging
- Removal of accumulated sediments, litter and debris from the sedimentation chamber
- Checking to ensure the weep holes (if provided) and overflow weirs aren't blocked.

To maintain the flow through a sand filter, it's essential to inspect regularly and remove the top layer of accumulated sediment. Inspections should be conducted after the first few significant rainfall events following installation and then at least every six months. Inspections will help to determine the long term cleaning frequency for the sedimentation chamber and the surface of the sand media.

Removing fine sediment from the surface of the sand media can typically be done with a flat bottomed shovel. Tilling below this surface layer can also maintain infiltration rates. The complete surface area of the sand filter must be accessible. This is a key consideration during the design stage.

Sediment accumulation in the sedimentation chamber must be monitored. Sediment deposition can overwhelm the chamber and reduce flow capacities, depending on catchment activities (e.g. building phase).

Debris removal is an ongoing maintenance function. Debris can block inlets or outlets, and be unsightly if located in a visible location. Inspection and removal of debris/ litter should be carried out regularly.

Sand Filters Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Litter within filter area?		
Scour present within sediment chamber or filter?		
Removal of fine sediment required?		
All structures in satisfactory condition (pits, pipes etc.)?		
Sediment requires removal from sedimentation chamber (record depth, remove if >50%)?		
Traffic damage evident?		
Evidence of dumping (e.g. building waste)?		
Clogging of drainage weep holes or outlet?		
Evidence of ponding (in sedimentation chamber or sand filter)?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		

Comments

Sample Case Study

Bellair Street Raingardens

Project summary

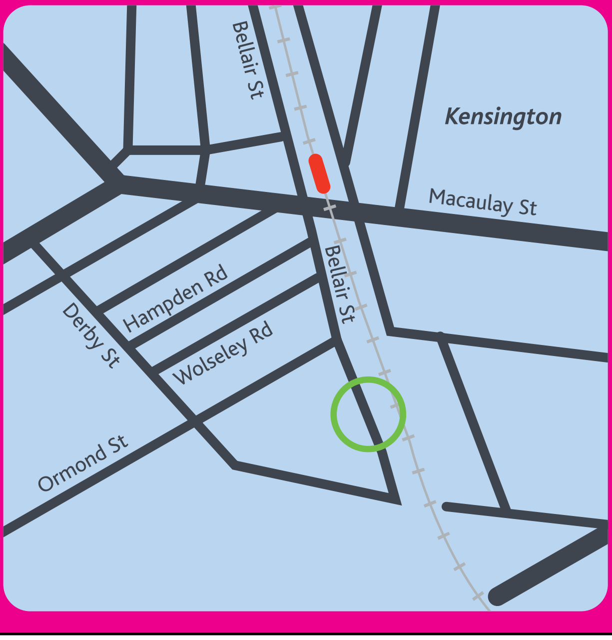
WSUD Type:	Raingarden tree pits
Scale:	Streetscape
Land Use:	Residential
Constraints:	Space, Topography, Vegetation
Cost:	$272,000
Performance:	Stormwater quality – 47.2%TN, 74.9%TP, 88.7%TSS, 100% Gross Pollutants

Site description

Location

The project is located in Bellair Street, Kensington, between Arden Street and Ormond Street as circled right.

Figure 1: Map showing location of the Bellair St, Kensington WSUD Raingardens



Site area

The road reserve is approximately 280m long by 15m wide.

Site land use

Bellair Street is a low density residential street with residential properties abutting the western edge and a railway reserve on the eastern edge.

The project proposed to:

- Renew the road surface, kerb and channel and footpath
- Replace some mature street trees suffering from structural defects and poor health.

Catchment description

The treatable catchment is 6540m^2, comprising the road reserve and abutting residential properties. The existing stormwater drainage system was used where available, however sections of new drainage were still needed. The high point is situated between Tennyson St and Arden St.

Part of the drainage runs to the existing drain in Arden St. The remainder was directed north to connect to the existing drain in Bellair St near the corner of Tennyson St. The treated water will ultimately enter Moonee Ponds Creek.

Topography/Terrain

Bellair St is relatively flat with a slight high point between Tennyson and Arden St.

Tennyson St slopes down to Bellair St from Southey St, forming part of this treatment catchment.

Site constraints

- Drainage gradients were limited by the relatively flat site topography
- Shallow stormwater pipe exist for approximately half of the site, with the rest requiring new stormwater pipe connection
- Not all existing trees could be removed, due to community request
- WSUD pit location and number needed to reflect the pre-existing tree placement
- Existing bluestone channel pitchers needed to be replaced
- Parking spaces were not to be reduced.

WSUD Design

Objectives

The project objectives were to:

- Upgrade the streetscape and renew infrastructure and vegetation;
- Treat stormwater to best practice;
- Maximise WSUD treatment size whilst not reducing available parking; and
- Ensure a low cost design.

Opportunities

If possible, the removal of all existing trees would:

- Provide a consistent aesthetic for the streetscape renewal (which also included the road, footpath, kerb and channel in addition to the tree renewal)
- Allow easier civil works.

The project also offered the opportunity to design and trial a larger version of the tree pit raingarden in a residential street setting. This context would require a less intensive treatment then the City of Melbourne's CBD tree pits.

Design development

Through extensive community consultation, the design was altered to allow four healthy plane trees to remain.

The kerb outstand raingarden also proved too difficult to include due to steep level changes and pedestrian crossing issues at a street intersection.

Final design

The final design included 19 raingardens, four less then the original concept design. It also excluded the kerb outstand raingarden.

Six of the raingardens required a reduced filter media depth due to the shallow depth of the existing stormwater pipe that was used to drain the raingardens. The final design still met the stormwater quality best practice treatment targets.

Figure 2: Section detail of Raingarden

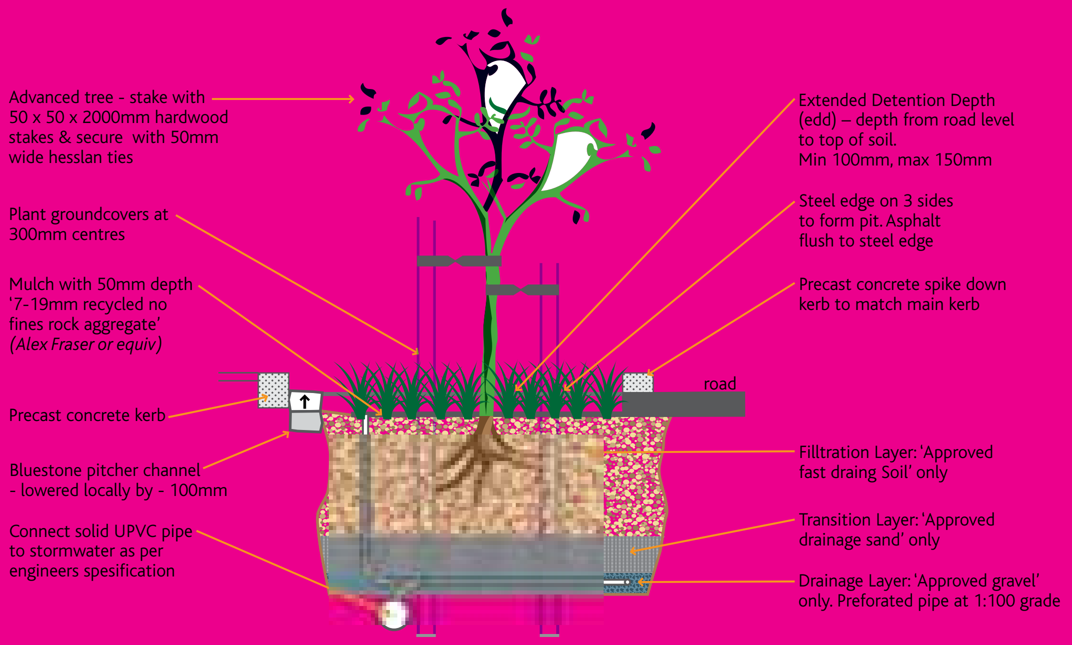


Figure 3: Plan view of raingarden showing drainage layout

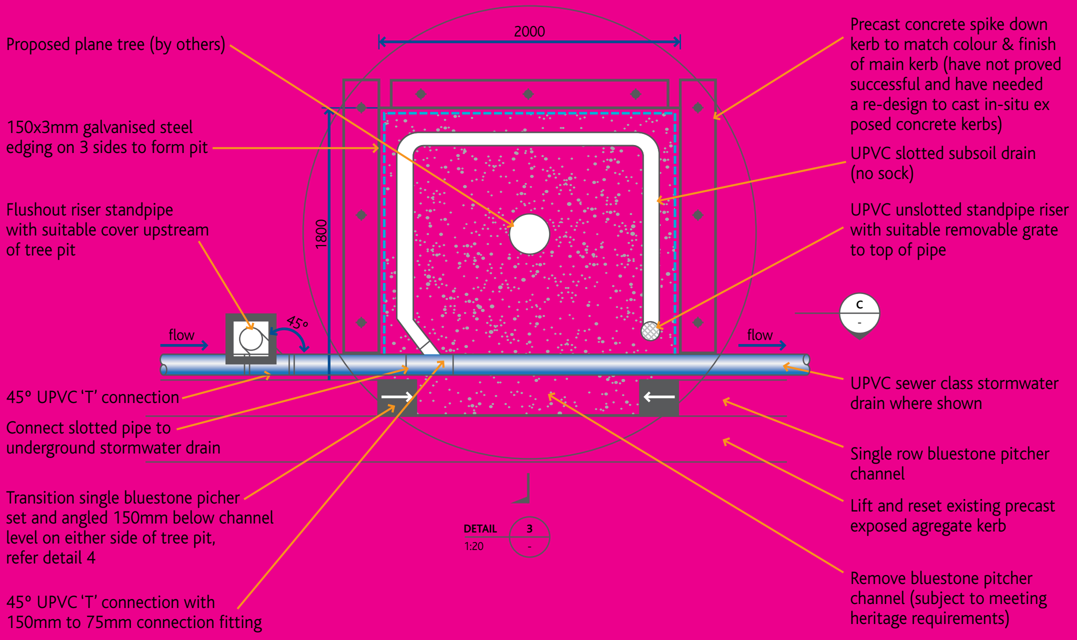
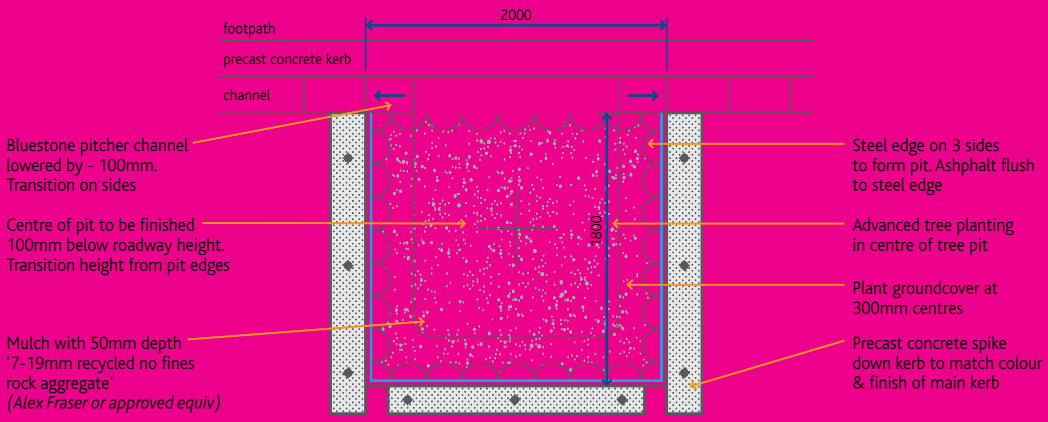


Figure 4: Plan view of raingarden showing surface details



Cost and timelines

The construction and installation costs of the raingardens have been kept at a minimum totaling approximately $1,300 per square metre. This cost can be further reduced where new stormwater drainage and boring is not required.

Table 1: Project cost and timelines

Task	Cost ($)	Completion dates	Undertaken by
Investigation (including concept design)	8,000	Late 2007	City of Melbourne Landscape design team with assistance from Melbourne Water
Detailed Design – WSUD	9,000	Feb 2008	City of Melbourne Engineering Services Group / Citywide / Connell Wagner
Detailed Design – Conventional	15,000	Feb 2008	City of Melbourne Engineering Services Group / Citywide / Connell Wagner
Construction – WSUD	90,000	June 30, 2008	City of Melbourne Engineering Services Group / Citywide / Ruccia Paving
Construction – Conventional	150,000	June 30, 2008	City of Melbourne Engineering Services Group / Citywide / Ruccia Paving
Implementation – (non-structural)		June 2008	City of Melbourne Tree Planning & WSUD Officer
Consultation/ Community Engagement		Feb – June 2008	City of Melbourne Tree Planning
Other (e.g. Evaluation)		July – Dec 2008	City of Melbourne Tree Planning & WSUD officer
Total cost	**272,000**		

Performance

The WSUD design exceeded the 'best practice' stormwater quality pollutant load reduction targets, as evaluated by the stormwater quality model, MUSIC.

Table 2 below show the MUSIC model results.

Table 2: MUSIC modelling

Pollutant	Treatment performance (kgs reduced)	Treatment performance (% reduced)	Best Practice Target (% reduced)
Total Suspended Solids	565.7	88.7	80
Total Phosphorous	0.987	74.9	45
Total Nitrogen	4.51	47.2	45
Gross Pollutants	122	100	70

Note: Load reductions are based on the 'typical urban annual load', as modelled by MUSIC.

Greenhouse impact

There are no ongoing CO2 emissions from this project. Embodied energy impacts exist from:

- Material choice (e.g. PVC pipes, sand and gravel)
- Transport.

Risk management/issues

The construction of raingardens into the streetscape falls into the usual scope of works for streetscapes and does not therefore pose any greater risk to traffic or pedestrians than usual civic works.

The sunken design of the raingardens has been mitigated as a pedestrian risk by the use of mulch topping and dense planting. This will need to be maintained.

The end use of the water is not for reuse purposes. It will be entering the stormwater and ultimately the waterway and will not be directly in contact with people. This negates the need to treat to high Class A standards. The design of the raingardens will treat the stormwater to a standard that reduces the risk to the environment by removing pollutants that would have otherwise entered the waterways.

Applicability

The project was designed so this form of raingarden could be used in other residential streetscapes outside the CBD area, where new trees need to be installed in the parking lane.

Post-project reflection

The exclusion of the kerb-outstand raingarden is regrettable. This could be avoided in the future by:

- Improved analysis of level changes between footpath, road and raingarden surface
- Firm Council policy on pedestrian safety for such systems.

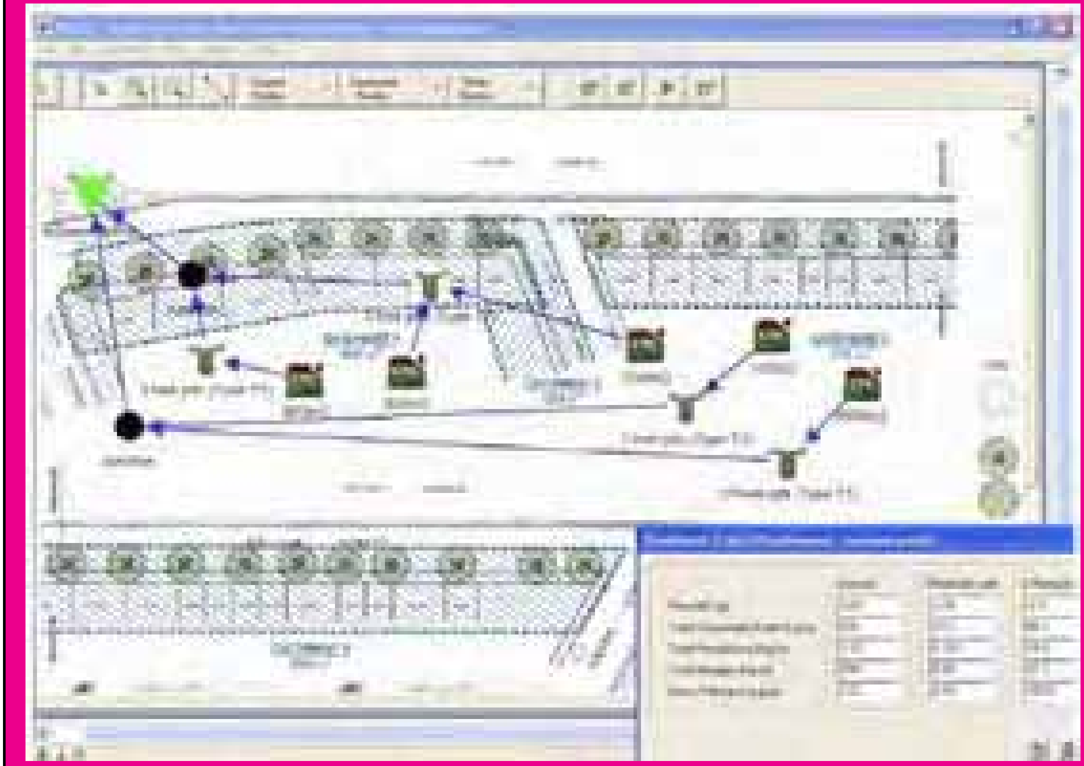
Maintenance requirements and issues

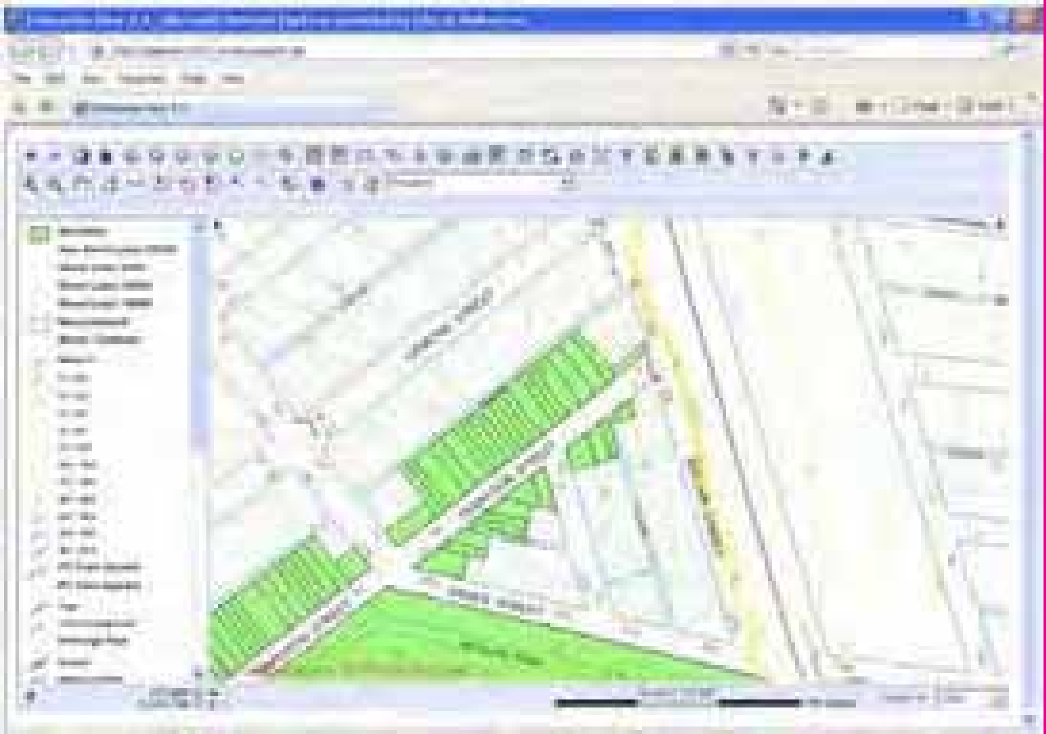
WSUD tree pit maintenance tasks are described in the table below.

Table 3: WSUD Tree Pit Maintenance Tasks

Parks Activity reports	Every 12 weeks	
ESG Activity reports	Every 12 months	
Inspection items	**Works tasks**	**Frequency**
Sediment accumulation at inflow points?	Remove or suck out sediments. Notify council if recurring problem to enable investigation of sediment source	12 weeks
Litter within pit?	Remove litter	4 weeks
Erosion at inlet or around tree?	Investigate why erosion is occuring. Top-up missing gravel mulch, top-up missing media (FAWB specification)	4 weeks
Traffic damage present?	Repair / replace missing or damaged parts Bollards needed?	4 weeks
Evidence of dumping (e.g. building waste)?	Re-instate media and vegetation as required to original specifications (FAWB specification).	4 weeks
Tree condition satisfactory (Foliage, bark, roots)?	Weed growth should be minimal. Spray with herbicide if necessary	4 weeks
Replanting required?	Re-instate and water as necessary.	4 weeks
Clogging of drainage points (sediment or debris)?	Remove leaves, litter or sediments	4 weeks
Evidence of ponding?	Rack top layer of the media and replace by sandy soil (FAWB specification). Infiltration testing may be required	12 weeks
Set down from pit cover still present?	Maintain / reinstate as per design level.	12 weeks
Damage/vandalism to structures present?	Repair / replace missing or damaged parts. Talk to an enforcement officer	12 weeks
Surface clogging visible?	Testing of infiltration media to ensure performance as specified.	12 months
Drainage system inspected?	Lift lids and inspect pits.	12 months
Resetting of system required?	Engage designer / consultant	5 -10 years

Diagrams of treated areas





Part 4

Water Sensitive Urban Design (WSUD) Fact Sheets

Household

1. Water sensitive homes
2. Household rainwater tanks
3. Sizing a rainwater tank
4. Porous paving
5. Site layout and landscaping

Developers, Council planners, architects, engineers

6. Water conservation initiatives
7. Waterway rehabilitation
8. Rainwater tanks
9. Gross pollutant trap
10. Sedimentation (settling)
11. Ponds and lakes
12. Vegetated swales and buffer strips
13. Raingardens
14. Raingarden tree pit
15. Surface wetlands
16. Subsurface flow wetlands
17. Suspended growth biological processes
18. Fixed growth biological processes
19. Recirculating media filter
20. Sand and depth filtration
21. Membrane filtration
22. Disinfection

Introduction

Part 4 of the Model WSUD Guidelines includes a list of Fact Sheets for either households or developers/council staff. They describe the likely benefits, different configurations, constraints and design considerations for a range of WSUD elements and include:

- Household Fact Sheets (Fact Sheets 1-5)
- Water conservation initiatives (Fact Sheet 6)
- Waterway rehabilitation programs (Fact Sheet 7)
- Treatment technologies:
  - Stormwater treatment (Fact Sheets 8 to 16)
  - Wastewater treatment for reuse (Fact Sheets 16 to 22).

WSUD elements discussed in this section cover a wide range of applications at different project (land) scales, including:

- Site level – runoff from single sites
- Precinct – groups of houses or streetscape scale
- Regional – applicable for larger scales where larger catchment areas are involved.

WSUD elements can also be categorised according to the user and application type to which they are typically relevant, as shown in the table below.

Application scale	Users	Development Type
Small	Householders	Residential
Medium	• Developers • Architects • Landscape architects • Engineers	Multi-unit and mixed use development
Large	• Developers • Architects • Landscape architects • Engineers	• Green fields • Brown fields • Large scale redevelopment • Commercial and industrial development
Broad	Council staff, including: • Engineers • Parks officers • Designers • Planners	Council landscapes such as parks and gardens, streetscapes, and public squares and plazas

Table 1 .WSUD elements, their Fact Sheet number and key selection characteristics

User	Fact Sheet number	Fact Sheet	Stormwater		Wastewater	Aesthetic value	Application Type			
			Quality	Retention			Small	Medium	Large	Broad
Household	1.	Water sensitive homes	–	–	–	–	•			
	2.	Household rainwater tanks	✓	✓	–	–	•			
	3.	Sizing a rainwater tank	✓	✓	–	–	•			
	4.	Porous paving	✓	✓	✗	✗	•	•	•	•
	5.	Site layout and landscaping	✓	✓	✗	✗	•			
Developers, Council planners, architects, engineers	6.	Water conservation initiatives	–	–	–	–	•	•	•	
	7.	Waterway rehabilitation	✓	✗	✗	✓		•	•	•
	8.	Rainwater tanks	✓	✗	✗	✗		•	•	•
	9.	Gross pollutant trap	✓	✓	✗	✓?		•	•	•
	10.	Sedimentation (settling)	✓	✓	✓?	✓	?	•	•	•
	11.	Ponds and lakes	✓	✓	–			•	•	•
	12.	Vegetated swales and buffer strips	✓	✗	✗	✓	•	•	•	•
	13.	Raingardens	✓	✗	✗	✓	•	•	•	•
	14.	Raingarden tree pit	✓	✗	✗	✓		•	•	•
	15.	Surface wetlands	✓	✓	✓?	✓		?	•	•
	16.	Subsurface flow wetlands	✓?	✓?	✓?	✓	•	•	•	
	17.	Suspended growth biological processes	✗	✗	✓	✗	?	•	•	•
	18.	Fixed growth biological processes	✗	✗	✓	✗	?	•	•	•
	19.	Recirculating media filter	✗	✗	✓	✗	?	•	•	
	20.	Sand and depth filtration	✗	✗	✓	✗	?	•	•	
	21.	Membrane filtration	✗	✗	✓	✗	?	•	•	•
	22.	Disinfection	✗	–	✓	✗	?	•	•	•

✓ = Primary purpose ✓? = Some impact but not primary purpose ✗ = Does not contribute
– = not applicable ? = possibly applicable • = applicable

Fact Sheet 1: **Water sensitive homes**

Small	Medium	Large	Broad
●			

What is a Water Sensitive Home?

Before we built houses, rainfall would naturally soak into the ground and slowly flow to our creeks and rivers.

Today, with so many houses and concrete surfaces, rain falling onto a houseblock or runoff from watering gardens flows to the nearest underground drain and piped quickly to the nearest creek carrying with it pollution that can harm our waterways.

The main components found in stormwater pollution are large quantities of substances such as nitrogen and phosphorus, heavy metals and fine sediments. Some of these pollutants are from natural sources, such as nitrogen from atmospheric deposition. Most however, are from garden fertilizers, litter, construction sites and cars. All of these are washed into waterways following rainfall.

The amount of stormwater pollution that is actually generated from a single house and garden is not high, but collectively our entire neighbourhood hurts our local waterway.

A suite of initiatives through Local Government, State Government and Melbourne Water are encouraging developers and builders to protect our waterways and bays from stormwater pollution through onsite Water Sensitive Urban Design stormwater treatment (WSUD). WSUD measures are simple treatment measures that collect, reuse and treat rainfall that falls onto your block. By improving the quality of stormwater before it reaches the local waterway, you are helping to:

- Delay and reduce the volume of stormwater discharge to streams
- Improve water quality in streams and groundwater
- Use water resources more efficiently
- Protect stream and riparian habitats
- Prevent erosion of waterways
- Protect the scenic and recreational values of streams

How do I make my home stormwater sensitive?

A stormwater sensitive home is one in which the dwelling and its surrounding land are designed and used so as to minimise harmful impacts on the natural water cycle.

By collecting and reusing stormwater in the home, and treating the stormwater to improve its quality before it leaves the houseblock, a stormwater sensitive home will help keep our rivers, streams and bays healthy.

The solution is simple and you are part of it.

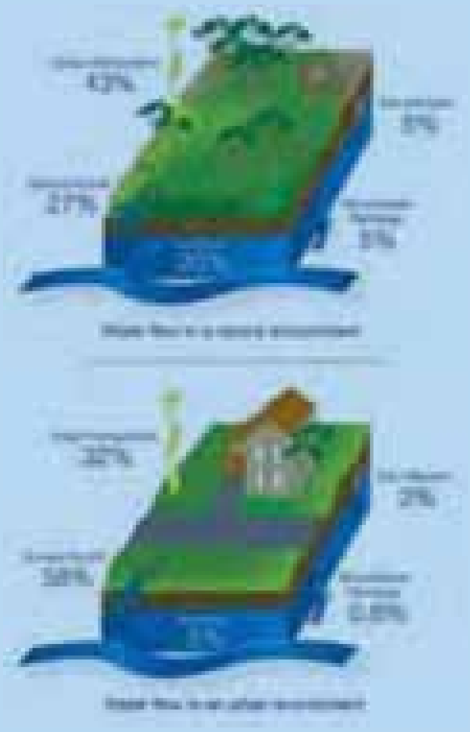
How do I improve the quality of stormwater leaving my block?

Improving the quality of stormwater that leaves your block can be achieved simply. Victorian standards for treating stormwater now exist and require the removal of 80% of suspended solids, 45% of total Nitrogen and 45% of total Phosphorus from stormwater runoff.

There is enormous scope for creativity when designing new homes or rebuilding an old one so that they incorporate a variety of WSUD treatments to meet the standards. Treatments can include rainwater tanks plumbed to a toilet, raingardens, or porus pavements installed instead of concrete pavements.

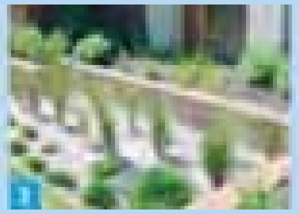
There are 4 additional fact sheets in this series that outline some of the commonly used stormwater treatment measures suitable for making your home stormwater sensitive.

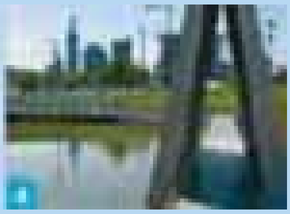
Changes to water flows in urban areas



Fact sheets include:

1. Rainwater tanks 2. Porus Paving 3. Raingardens 4. Site layout and landscaping





Fact Sheet 2: **Household rainwater tanks**

Small	Medium	Large	Broad
•			

How does a rainwater tank help protect our local streams?

Most people install a rainwater tank primarily to harvest stormwater from their roof and conserve their mains water use. In addition to conserving water, a rainwater tank also helps treat stormwater and protect local streams from high storm flows by reducing the volume of stormwater and quantity of pollutants coming from a house block that would otherwise be delivered to the local stream.

What do I use my tank water for?

Garden irrigation, laundry and toilet flushing consume much of our home water use. In most cases these uses do not require the water to be of drinking quality standard that is provided by mains water. By plumbing your rainwater tank to your toilet or laundry and substituting these mains water needs with the rainwater harvested from your roof, you can conserve mains water whilst reducing the amount of stormwater that enters our streams.

Why can’t I use my rainwater tank for my garden alone?

So that your tank is not too full to collect rainwater when it rains, you need to be consistently using your tank water all year round.

If tank water is used for your garden alone, your tank will remain full and unused during the winter months when your garden does not require watering. With a full tank, your capacity to capture and store the regular winter rainfall and thus benefit the local waterway is significantly reduced.

By plumbing your rainwater tank to your toilet or laundry, your tank water is used consistently all year round allowing rainfall to refill the tank more often especially in winter. This ultimately reduces the volume of stormwater that is delivered to the stream and the quantity of pollutants that are washed with it.

The Victorian Government has recognised the importance of plumbing your tank to your toilet and offers a cash rebate for the installation of connected rainwater tanks (www.dse.vic.gov.au). In addition, a 5 star energy standard has been introduced that requires a connected 2000Lt rainwater tank or solar hot water service to be installed in all new houses and apartments (class 1 and 2 buildings). (www.buildingcommission.com.au).

How do I choose a rainwater tank?

The most important thing to consider when choosing a rainwater tank is to first identify what you want from your rainwater tank. The size and type of rainwater tank you choose will vary depending on your homes water needs and the reliability you seek from your rainwater tank supply. There are a number of factors that may influence this and the following questions should be considered when planning your tank installation:

- what is the water demand of your home?
- how many people are living in your home?
- what is your intended use of rainwater?
- what reliability do you want from your tank?
- what is the total area of roof draining into your tank?
- what is average rainfall of your area?
- do you need extras like a pressure pump, the ability to top up your tank with drinking water, a backflow prevention device or a first flush device?
- are the materials used on your roof suitable to collect rainwater?
- are there physical constraints of your property that may influence the type of rainwater tank you need?

Once you know how much water you can collect and how much water you are going to use then a tank size can be selected to provide the reliability of water supply that you need.

Fact Sheet 2: **Household rainwater tanks**

Types of rainwater tanks

Rainwater tanks come in a variety of materials, shapes and sizes and can be incorporated into building design so they don't impact on the aesthetics of the development. They can be located above ground, underground, under the house or can even be incorporated into fences or walls.

There are three main tank systems to consider and a variety of materials to choose from. Features of these are outlined below and in the pictures above:

Tank systems:

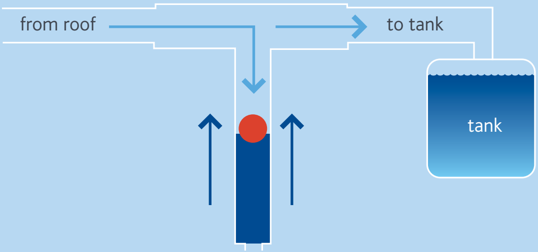
Gravity Systems - rely on gravity to supply rainwater to the household and the garden by placing the tank on a stand at height.

Dual Supply Systems - top your rainwater tank with mains water when tank level is low ensuring reliable water supply.

Pressure Systems - use a pump to deliver rainwater to household and garden fixtures.

To reduce the amount of sediment and debris entering a tank, mesh screens and 'first flush diverters' can be fitted. A screen will filter large debris such as leaves and sticks while 'first flush diverters' store the 'first flush' of the rainfall that carries the sediment and other pollutants initially washed from your roof (see figure below).

First flush diverter added to a tank



Costs & rebates

Costs of installing a tank vary however a standard 2000Lt tank or bladder will cost around $1000.

Additional plumbing and/or...

- Above ground tanks cost approximately $250 for a 500 litre tank.
- Below ground tanks cost between $300-$600 per 1000 litres of storage
- The costs of pumps start from $200.

Additional plumbing and/or excavation costs vary on intended use, pipe layout, materials and site accessibility.

The Victorian Government offers a total rebate of $300 for the installation of a rainwater tank that is plumbed to toilet and connected by a licensed plumber. For further details refer to the Department of Sustainability and Environment website www.dse.vic.gov.au.

Fact Sheet 3: **Sizing a rainwater tank**

Small	Medium	Large	Broad
●			

The effectiveness of a rainwater tank installation is influenced by:

- How often it rains (rainfall patterns or rainfall frequency)
- How hard it rains (rainfall intensity).

There are two key questions that affect the size of the tank:

- How big is your roof?
- How will the water be used (for toilet flushing or garden watering)?

How to calculate appropriate tank size

1. Calculate roof area (m^2)
2. Decide if you are using the water for toilet flushing, garden use, or both.

Toilet flushing

- Calculate how many people per $100m^2$ of roof area
- Read off the supply reliability for desired tank size.

Outdoor use

- Calculate the garden area that you water
- Determine garden area per 100m of roof area

Example: Toilet flushing

A typical household example is shown below.

- Roof area = 250 m^2
- Desired reliability of supply (to meet demand) = 90%
- Rainwater is to be used for toilet flushing
- There are four people in my household.

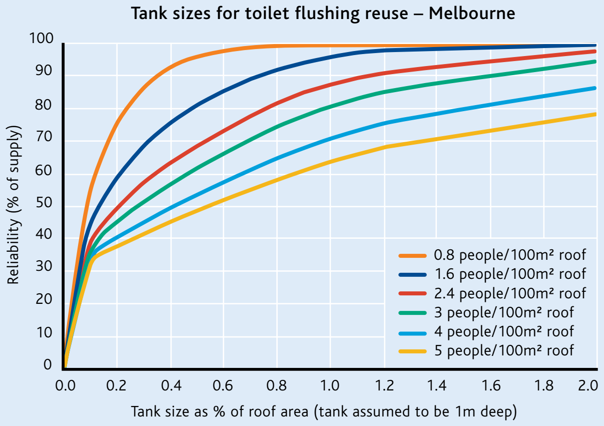
Step 1 Convert the number of people to per $100m^2$ roof area: 4 people per 250 m^2 = 1.6 people per $100m^2$

Step 2 Use the toilet flushing tank sizing curve below to work out how to achieve 90% reliability:
I need a tank that is approximately 0.8% of $250m^2$ = 2 m^2

Step 3 Calculate the tank area: $2m^2$ x depth 1m = $2m^3$ (2 kL).

Result On average, a 2kL rainwater tank will meet my household's flushing requirements.

Figure 1: Rainwater tank sizing curve for toilet flushing in Melbourne



Example: Outdoor use

A typical household example is shown below.

- Roof area = 150 m^2
- Desired reliability of supply (to meet demand) = 50%
- Rainwater is used for outdoor use
- Garden area is 250 m^2 but I only water $120m^2$ of my garden (so I use this figure).

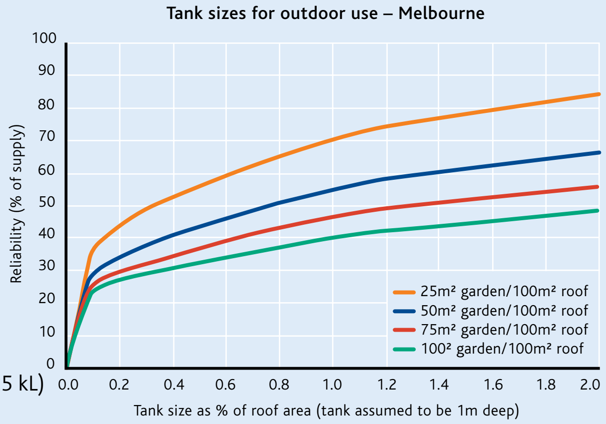
Step 1 We need to work out the amount of garden area per $100m^2$ of roof area. Divide garden area by roof area and multiply by $100m^2$, i.e: $120m^2/1.5$ = 80 m^2 garden area per $100m^2$ of roof area

Step 2 Use the outdoor tank sizing curve below to work out how to achieve 50% reliability:
I need a tank that is approximately 1.5% of the $150m^2$ = 2.25 m^2.

Step 3 Calculate the tank area: $2.25m^2$ x depth 1m = $2.25m^3$ (2.25 kL)

Result On average a 2.25kL rainwater tank will supply 50% of my outdoor watering requirements.

Figure 2: Rainwater tank sizing curve for outdoor use in Melbourne



MUSIC and STORM modelling programs

MUSIC is a stormwater modelling program which can calculate sizing curves for tanks based on historical rainfall data for a location. The water use can be set as constant (e.g. toilet flushing) or to vary with the season such as garden watering. Outdoor use is typically greater in summer and the 'outdoor curve' accommodates this variation.

MUSIC can be accessed at http://www.toolkit.net.au/music, but requires a licence (a trial version is available free for a limited time).

STORM is an online calculation tool from Melbourne Water which is based on MUSIC results. This provides reliability estimates for tanks based on roof area, tank size and location within Victoria. Changing these parameters until the desired reliability is achieved will provide the tank size required.

STORM can be accessed free at: http://storm.melbournewater.com.au/.

Installation

A licensed plumber is required to install the rainwater tank with all installations conforming to Australian standards (AS3500.1.2 Water Supply: Acceptable Solutions)[33].

Planning approvals and building permits

Insert information on the planning approval process for rainwater tanks in your Council.

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[33] Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for additional information.

Fact Sheet 4: **Porus paving**

Small	Medium	Large	Broad
●	●	●	●

Why install porous pavements?

In urban environments, paved surfaces such as roads, driveways and courtyards cover a significant area. These 'impervious' surfaces do not allow rainfall to soak through them to the underlying soil and as a result contribute to larger amounts of stormwater entering into our streams than would otherwise naturally occur. These stormwater flows carry with them pollution that has been washed off from roads, pavements and roofs. The rapid pace that stormwater is delivered to the stream contributes to bank erosion and habitat scouring.

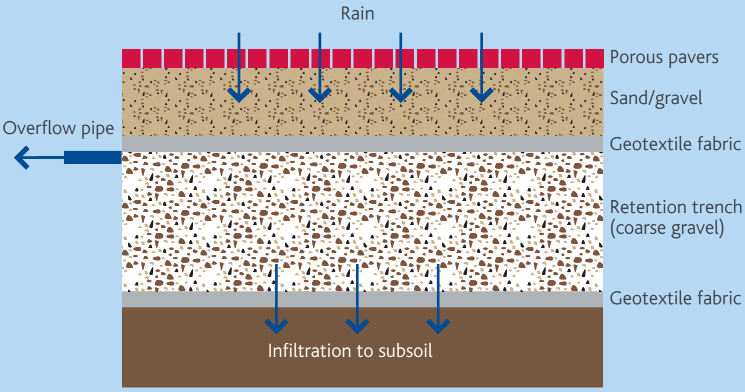
To protect our streams from this occurring, we need to reduce the amount of 'impervious' surfaces in our urban areas so that less water and pollutants are washed off and delivered quickly to the stream.

One way to do this is to install porous pavements instead of traditional concrete pavements in our backyards and driveways. Porous pavements reduce the amount of runoff by allowing water to soak through the surface and into the underlying soil.

How porous paving works

By using porous paving that allows rainwater to soak through to the soil instead of standard concrete or block pavers, you can:

- reduce the amount of 'impervious' surfaces on your block
- increase groundwater recharge by allowing the water to soak through the soil
- improve stormwater quality by filtering stormwater and reducing pollutant loads
- reduce high flows entering the waterway from urban areas causing stream erosion and habitat scouring



How does porous paving work to treat stormwater?

Porous paving is installed just like traditional paving and comes in many forms. It can be asphalt, or modular pavers that are concrete, ceramic or plastic.

Porous paving contains surface voids that are filled with sand or gravel that filter the stormwater. They overlay a gravel retention trench that allows greater capacity to retain stormwater. During heavy rain, excess stormwater overflows to the street drainage systems when the trench becomes full.

To maximise its capacity to allow water to soak through to the underlying soil, porous pavements should not be installed over rock or other substrate that has little or no capacity to allow water to infiltrate through it.

Maintenance

Concrete grid, ceramic and modular plastic block pavers require less maintenance than asphaltic porous paving as they are less easily clogged by sediments. To ensure their effectiveness and lifespan, porous paving should be:

- Protected from 'shock' sediment loads especially during and shortly after construction when clogging may occur
- Inspected for cracks and holes and replaced as necessary
- Cleaned from accumulated debris and sediment
- Weeded or mowed where appropriate (largely for aesthetic purposes)

When properly maintained porous paving should have an effective life span of at least 20 years.

Costs

Costs of porous paving depend on the type of material used and range from $70 - $120 per sqm. (Melbourne Water, 2005). Cost to install porous pavements are similar to other pavements.

Fact Sheet 5: **Site layout and landscaping**

Small	Medium	Large	Broad
●			

Incorporating water sensitive measures

There is enormous scope when designing new homes and retrofitting existing homes to incorporate water sensitive measures such as rainwater tanks, porous pavements and raingardens. By thinking about your site and its features before you begin, you can make the most of layout opportunities for your treatment measures. Things to consider when making your home stormwater sensitive include:

1. Natural site factors
2. Choice of treatment measures
3. Plant selection
4. Protection during construction

What to consider when designing the layout of your stormwater sensitive site

1. Natural site factors

Understanding your sites topography, rainfall, existing drainage patterns, expected flows, soil, vegetation and sun/shade patterns before you begin can help you plan the layout of your stormwater treatment measures. By understanding and incorporating the natural site features of your site into your design, you can maximize the effectiveness of your treatment measures whilst creating aesthetically pleasing surroundings for your home.

2. Choice of treatment measures

Runoff from your block mainly comes from your roof and pavement. Rainwater tanks, raingardens, buffer strips and porous pavements call all be used to treat rainwater runoff. Exactly how your site ultimately looks will depend on your creativity, individual needs and the individual site factors you are working with. There is a lot of scope to be creative in your layout and it is important to remember that you are not constrained by using just one treatment measure. You may choose to collect runoff from your roof and direct it to a raintank to supply water for toilet flushing, or you may choose to direct your roof runoff to a raingarden. You may even choose to do both. By knowing the amount of rain and runoff you receive and where you sun and shady areas are will help you to design the best layout for your stormwater treatments whilst creating the home surroundings you desire.

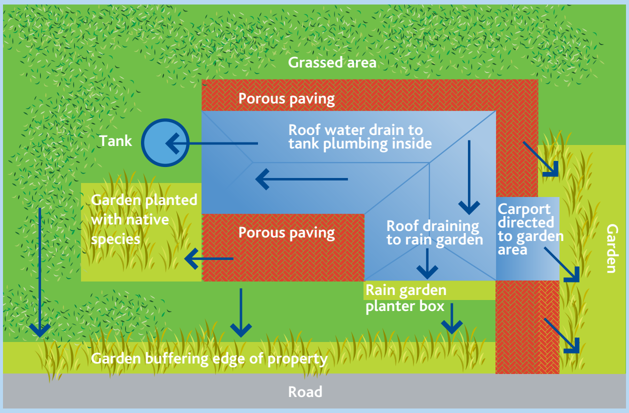
3. Plant selection

A wide variety of plants are suitable for your stormwater treatment measures with characteristics that incorporate the necessary treatment function and your aesthetic preferences. Choice of plants will depend on your visual preferences coupled with their suitability to your sites soil and climatic conditions whilst withstanding periods of soil saturation and anaerobic conditions. Preference should be given to local native species and it is wise to check with your council that the plants you choose are not environmental weeds in your area.

4. Protection during construction

It is important to protect both your stormwater treatment measures and the stormwater drains from excess sediment being washed into them during the construction phase of your site. Without adequate protection during this time, stormwater treatment measures can become clogged with dirt and soil washing from your site. Clogging risks their ability to adequately treat stormwater and it is likely that the clogged treatment measure will will need to be cleaned out. Using sediment fences to capture dirt and soil coming from your site is an easy way to protect your stormwater treatment measures, and your local stream from being smothered by if loads are not captured along the way.

By considering your site factors before you begin it is possible to create a stormwater sensitive home that suits your individual needs. The figure (right) shows one possible overall water sensitive strategy for a typical suburban home. A rainwater tank collects half of the roof runoff and is plumbed to supply rainwater for toilet flushing and outdoor use. The remaining roof runoff is directed into a raingarden. Stormwater runoff from paths, driveways and lawns is directed to garden areas. Concrete impervious pavements have been replaced with porous pavements and a buffer garden area is protecting any excess runoff from reaching the road and into the conventional stormwater drainage system.



Fact Sheet 6: **Water conservation initiatives**

Small	Medium	Large	Broad
●	●	●	

Supplying potable (drinking) water to Melbourne is increasingly becoming a difficult task. There is already a strain on existing water resources. New development will put further pressure on potable water resources unless demand is reduced.

Finding sources of potable and reusable water

Matching the intended use of the water to its required quality (and therefore its source) achieves the most significant savings for potable water demand. Most domestic, commercial and industrial water does not need to be of potable quality. Depending on what water is required for, it could come from different sources.
These include:

- Roof runoff/rainwater tanks
- Greywater (from laundry and bathroom)
- Reclaimed water (from local wastewater treatment plants)
- Recycled plant water (at an industrial premise).

Consider the following issues when determining an appropriate source of reuse water:

- Availability of secondary source
- Proximity to use
- Potential cost of construction of extra infrastructure
- Risk of cross connections between potable and reused water (health impacts)
- Treatment requirements before reuse
- Application usage and method of the reused water
- Broader environmental objectives (including greenhouse emissions).

Prioritising options for water reuse

A hierarchy of options for water reuse is listed below. The options are ordered from the easiest to implement to the most extensive water reuse. To determine the best option for a development, consider the:

- Scale of the development
- Proximity to treatment facilities
- Pressure on potable water demand.

The recommended hierarchy for household reuse options is:

1. Rainwater reuse for the toilet and garden
2. Rainwater for hot water, household greywater for garden and toilet
3. Stormwater reuse for garden
4. Recycled water to toilet and garden, rainwater for hot water.

The alternative water source hierarchy has been set out in a broader context in Module 2.2 Scoping the Options of the WSUD Guidelines.

Managing demand

Make better use of water to achieve significant savings through:

- Changes in consumer behaviour
- Use of water efficient devices.

Education initiatives are the best way to change behaviour. Usually they are carried out by local water authorities.

Insert any Council education initiatives on demand management

Fact Sheet 6: **Water conservation initiatives**

The WELS (Water Efficiency Labelling and Standards) scheme

Melbourne households generally don't use water efficiently. The WELS (Water Efficiency Labelling and Standards) scheme rates the water efficiency of water appliances such as:

- Showerheads
- Washing machines
- Toilets
- Dishwashers (one to six 'stars' are given).

The scheme increases the use of water efficient devices and encourages improved practices in residential dwellings.

Water usage (per litre) must be part of product labelling, according to the scheme. The more water efficient the product is, the more stars it will have. This is similar to the energy efficiency rating.

More information on the WELS scheme can be found online at www.waterrating.gov.au. The Green Plumbers are a good source of water saving assistance in the household. Call 1800133871 or log onto: www.greenplumbers.com.au

Reducing consumption

A reduction of around 15-40% in water consumption can be obtained by:

- Adopting water efficient appliances and fittings
- Changing behaviour.

Garden designs that use water efficiently through plant selection and zoning of vegetation types can also reduce water demands considerably. Using indigenous vegetation can vastly reduce irrigation.

For advice on sustainable gardening, visit a nursery that is accredited by Sustainable Gardening Australia www.sgaonline.org.au

For more information on householder initiatives, refer to Fact Sheets 1-4.

Fact Sheet 7: **Waterway rehabilitation**

Small	Medium	Large	Broad
	●	●	●

Waterway rehabilitation aims to mimic the natural waterway system. Important considerations include:

- Vegetation selection
- Stabilisation of the waterway
- Adequate flood conveyance
- Appropriate hydrologic regime.

Community value

Rehabilitated waterways can be very popular recreation areas within communities (e.g. Elwood Canal-Elster Creek and Albert Park Lake). Frequently used as linear parks, they:

- Attract walkers, bike riders, bird watchers
- Provide urban retreats
- Help to promote appreciation of waterways and their ecological values
- Can improve property values of surrounding areas.

Hydrologic conditions

In the Council Name, the hydrologic regime of waterways has been drastically changed. In the short term, it's not possible to return a waterway to pre-urbanisation conditions.

Pollutant control

Upstream runoff frequently requires some pollutant control, particularly for litter, debris and coarse sediments. These can impact the aesthetics of a waterway as well as smothering habitats, generating odours, attracting pests and depositing dangerous materials.

Fact Sheet 8: **Rainwater Tanks**

Small	Medium	Large	Broad
	●	●	●

Rainwater tanks collect water runoff from roof areas. They can provide a resource of non-potable water in the Council Name.

Tank design

Tanks can be incorporated into building design so they do not impact on the aesthetics of a development or the surrounding environment. They can be:

- Sympathetic to heritage areas
- Located underground
- Incorporated into fence or wall elements.

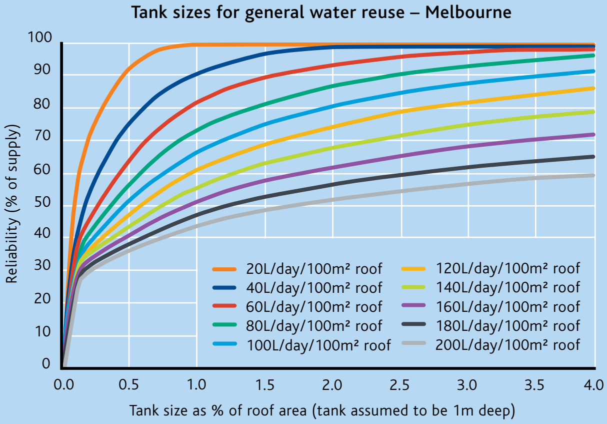
Tank sizing

In general, tanks are sized according to their intended demand and available roof catchment. For example, if tank water will be used for toilet flushing and hot water systems, the right size of tank can achieve the desired level of reliability.

Figure 1 use Melbourne rainfall data and typical demand values (from 3 star rated appliances). The curves size tanks relative to the roof area and the occupancy rate. Generally rainwater harvesting becomes unfeasible if the roof area is less than $15m^2$ per person.

If the water demand (or occupancy number) and roof areas are known, a tank can be selected with reference to Figure 1. Use the reliability of supply (percentage of water needs supplied) to work out optimal tank size. Marginal gain is attained by installing a tank larger than approximately 2-4% of roof area (dependent on demand). The increased tank size and cost must be evaluated against additional potable water conservation.

Figure 1: General use tank sizing curve for Melbourne



Inner city residential tanks

An inner city residential tank is usually 1.5 to 3 kL (kilolitres). However this depends on roof area and water use.

Use a top up from potable water supplies to cover the shortfall in demand. This is achieved by:

- Plumbing potable water into the tank with an air gap
- Having a float activated switch
- Preventing cross contamination by using appropriate valves.

Integrated management systems are available that can automate rainwater use throughout the household.

Installation

Rainwater tanks can be fitted with 'first flush diverters'. These are simple mechanical devices that divert the first portion of runoff volume (that typically carries debris and contaminants) away from the tank. After the first flush diversion, water passes directly into the tank. Collected roof runoff water is suitable for direct use for garden irrigation or toilet flushing with no additional treatment. Tank water can also be used in hot water systems, although some additional treatment to remove the risk of pathogen contamination is required. This generally involves UV disinfection, and ensuring that the hot water service maintains a temperature of at least 60-70°C, subject to Council Name approval. A licensed plumber is required to install the rainwater tank with all installations conforming to Australian standards (AS3500.1.2 Water Supply: Acceptable Solutions)[34].

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[34] Refer to the Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) for additional information

Fact Sheet 8: **Rainwater Tanks**

Planning approvals and building permits

Insert information on the planning approval process for rainwater tanks in your Council

Fact Sheet 9: **Gross Pollutant Traps (GPTs)**

Small	Medium	Large	Broad
•	•	•	

Gross pollutant traps (GPTs) are commonly installed by council and developers to manage stormwater pollution.

GPTs retain litter and debris from stormwater systems primarily through screening. Some GPTs also remove bed load sediments and some suspended sediments through rapid sedimentation.

GPTs are mainly used in existing conventional drainage systems either in pipes, at outfalls, or in open channels. However, they can also be used as 'pre-treatments' for other WSUD elements. They aim to retain solid litter that has washed into the system but not retard flows or increase water levels in the drainage system considerably.

Many WSUD elements don't need a GPT. In particular, when there is streetscape and source control measures buffering the stormwater drainage system from contributing areas, the entry of litter and debris to the stormwater system is restricted by filtration media. However, GPTs can be used in WSUD as a pre-treatment device when piped systems discharge into waterways or wetlands.

Selecting a GPT product

Unlike other WSUD elements, a wide range of commercial GPT products are available from more than 15 suppliers in Australia. Different GPTs employ varying mechanisms of litter separation and containment and their performances can vary greatly. There are also GPTs intended for different catchment scales – from less than one hectare to more than 100 hectares. It's important to select an appropriate GPT depending on specific conditions.

Sizing

Isolating high pollutant load generation areas is the key to locating a GPT. Use hydraulic considerations to size a GPT and minimise the amount of 'clean' water that is treated. GPTs are generally sized to treat between the 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% of annual runoff volume.

Type and brand

To decide on the type (and brand) of GPT, you need to balance:

- Life cycle costs of the trap (i.e. by combining capital and ongoing costs)
- Expected pollutant removal performance (in regard to the values of the downstream water body)
- Any social considerations (e.g. public safety and aesthetics).

Cost

Use a life cycle cost approach that considers ongoing operation costs and the benefits of different traps assessed over a longer period. The overall cost of GPTs is often more heavily influenced by maintenance rather than capital costs.

Maintenance

Regular maintenance (cleaning) of GPTs is essential for their successful operation.

There is a maintenance commitment when a GPT is installed. Generally, this is at least a 'clean out' every three months. However, it depends on the catchment characteristics and any source reduction initiatives that may be active in the area.

A poorly maintained GPT will not only cease to trap pollutants, but may release contaminants by allowing leaching from the collected pollutants.

Fact Sheet 10: **Sedimentation (Settling)**

Small	Medium	Large	Broad
	●	●	●

Waterway Sedimentation removes pollutants in water through gravity settling. Sedimentation systems reduce flow velocities and encourage particles to settle out of the flow. Coarse particles are removed more easily than fine particles. However a well performing sedimentation system will let finer particles aggregate and then settle.

Sedimentation happens in many WSUD elements.
For example:

- Sediment basins
- Tanks (storage tanks, balancing tanks, rainwater tanks, stormwater tanks)
- Ponds and lakes
- Wetlands.

All elements reduce flow velocity, increasing the retention time of the water and the settling of particles.

Design considerations

The key design parameters are:

- Sediment's terminal settling velocity (primarily dependent on particle size)
- Hydraulic information (water velocity, flow rate and retention time).

The sediment separation device can then be sized. For finer particles, characteristics such as their size, shape, structure and charge have a greater impact on removal.

Sediment basins

Sediment basins are used to retain coarse sediments from runoff. They are typically incorporated into pond or wetland designs such as the 'exclamation mark wetland' at the National Australia Bank forecourt at Docklands.

During periods without rainfall, the basins can drain and then fill during runoff events. They are often used during construction activities and as pre-treatment for elements such as wetlands (e.g. as an inlet pond).

Sizing

Basins are sized according to the design storm discharge, and generally designed to trap coarse sediments only (particle size greater than 0.125mm diameter). The large volumes of coarse sediments carried in stormwater require regular removal from the basin. These have generally low contaminant concentrations and should be kept separate from the fine sediments. Fine sediments have the highest contaminant (hydrocarbon and metal) concentrations and higher waste disposal costs. Therefore sediment basins are mainly designed to retain coarse sediment.

Maintenance

Sediment basins must be maintained every two to five years, depending on the catchment. This generally involves draining the basin and excavating collected sediments for landfill. To drain the basin, either a sump is required in the design, or the sediment can be pumped, depending on the size. An access point for suitably sized excavators is also needed.
For construction sites that produce very large sediment loads, de-silting is required more frequently. A sediment basin will generally require resetting after construction in the catchment area is complete.

Location

Available space and suitable topography are the two main considerations when locating a sediment basin. However temporary basins can be constructed as 'turkey nest' basins. 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, a multiple level off-take riser will regulate flow to a wetland or pond.

Design

Depth can minimise vegetation (weed) growth and allow for adequate collected sediments storage, usually a minimum of one metre. Detailed design specifications are available from the *WSUD Engineering Procedures: Stormwater manual*[35].

Tanks, ponds and wetlands

Physical separation by sedimentation occurs in tanks, ponds and wetlands, primarily due to reduced flow velocities and still conditions. For more information, refer to the appropriate Fact Sheet.

Advanced sedimentation systems

More advanced sedimentation devices such as clarifiers can be incorporated into black, grey and sewer mining water treatment processes. These devices are typically a combination of mechanical and physical designs that enhance sedimentation and reduce the necessary footprint.

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[35] Available for purchase from Melbourne Water's website (http://wsud.melbournewater.com.au)

Fact Sheet 11: **Ponds and Lakes**

Small	Medium	Large	Broad
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Ponds and lakes are artificial bodies of open water usually formed by a simple dam wall with a weir outlet structure.

Ponds in the Council Name can be integrated into the WSUD strategy. Not only do they provide an aesthetic quality, but they also provide a function.

Typically the water depth is greater than 1.5m. There is usually a small water level fluctuation, although newer systems may have riser style outlets. This allows for extended detention and longer temporary inflows storage.

Usage and benefits

Ponds promote:

- Particle sedimentation
- Adsorption of nutrients by phytoplankton
- UV disinfection.

Ponds provide valuable water storage that can potentially be reused as irrigation. Often wetlands will flow into ponds and the water body enhances the local landscape and can provide a wildlife habitat. Ponds or lakes can also be focal points in developments, with houses and streets having aspect over open water.

Ponds can be used for water quality treatment. In particular, ponds are useful in areas where wetlands are unfeasible e.g. very steep terrain. In these cases, ponds should be designed to settle fine particles and promote submerged macrophyte growth.

Vegetation

Aquatic vegetation has an important function in water quality management in ponds and lakes. Fringing vegetation is necessary to reduce bank erosion, and is aesthetically pleasing. However it has minimal contribution to water quality improvement.

Stormwater treatment

Ponds are seldom used as "stand-alone" stormwater treatment measures. As a minimum, ponds require pre-treatment with sediment basins. These basins require regular sediment removal (refer to the *Sedimentation (Settling) Fact Sheet* for more details).

Hydrologic conditions and inflow water quality

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 needed to track the fate of nutrients and consequential algal growth in the water body during periods of low inflow (and therefore long detention period).

As a general rule, the mean turnover period for lakes during the summer periods should be less than 30 days, i.e. the lake volume should not be greater than the volume of catchment runoff typically generated over a 30 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 is often an urban design desire to maximise the size of the pond as a focal water feature for a residential development.

Further information

Additional Information for developers can be obtained from Melbourne Water's *Constructed Shallow Lake Systems – Design Guidelines for Developers* available online at www.melbournewater.com.au/content/library/rivers_and_creeks/wetlands/Design_Guidelines_For_Shallow_Lake_Systems.pdf

Fact Sheet 12: **Vegetated swales and buffer strips**

Small	Medium	Large	Broad
●	●	●	●

Swales

Vegetated swales can be used instead of pipes to convey stormwater and provide a 'buffer' between the receiving water
(e.g. Port Philip Bay, river, wetland) and the impervious areas of a catchment.

Swales can be integrated with:

- Landscape features in parks and gardens
- Street designs to add to the aesthetic character of an area.

Pollutant settlement

As water flows over vegetation, it's evenly distributed and the flow retarded. This encourages pollutant settlement and retention in the vegetation. Total nitrogen (TN) is generally the hardest pollutant to remove in swale systems.

Flood flows

Pits draining to underground pipes can be used to convey flood flows, in excess of the treatment design flow. Water overflows from the swale into a pit.

Slope

The longitudinal slope of a swale is an important consideration. Slopes from 1% to 4% are recommended. Slopes milder than this can become waterlogged and have stagnant ponding (although the use of subdrains can alleviate this problem). Where slopes are steeper than 4%, check banks along swales, dense vegetation and/or drop structures can help to distribute flows evenly across the swales and slow velocities.

Cross-section

Swales with trapezoidal cross-sections usually achieve better treatment outcomes than those with triangular cross sections.

Design issues

Design for swale, road or driveway cross overs must be carefully considered. Driveway cross overs can be:

- An opportunity for check dams (to provide temporary ponding)
- Constructed at grade to act like a ford during high flows.

Vegetation type

Many different vegetation types can be used in swales. Vegetation should:

- Cover the whole width of the swale
- Be capable of withstanding design flows
- Be of sufficient density to provide good filtration
- Be selected to be compatible with the landscape of the area and maintenance capabilities.

For best performance, vegetation height should be above the treatment flow water level. Some examples are shown in the pictures.

Maintenance

Maintenance requirements are typical of standard landscaping. Vegetation growth and litter removal are the key objective.

Nitrogen removal

Swales are typically limited by their effectiveness in reducing total nitrogen levels. A bioretention swale may help if greater nitrogen removal is required (see the Raingardens Fact Sheet for further details).

Sizing curves

Sizing curves relate the swale performance to a percentage of the impervious catchment area to be treated. They relate the vegetation height (Figure 1) and the swale slope (Figure 2) to the TN removal. The sizing curves are used to assess the top width of the vegetated swale.

Fact Sheet 12: **Vegetated swales and buffer strips**

Figure 1. TN reduction by a swale in Melbourne as vegetation varies (3% slope)

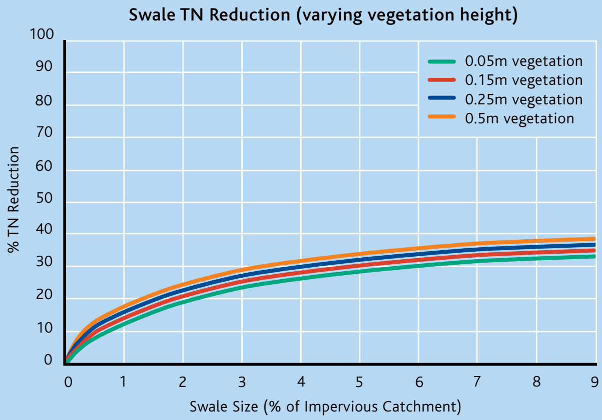
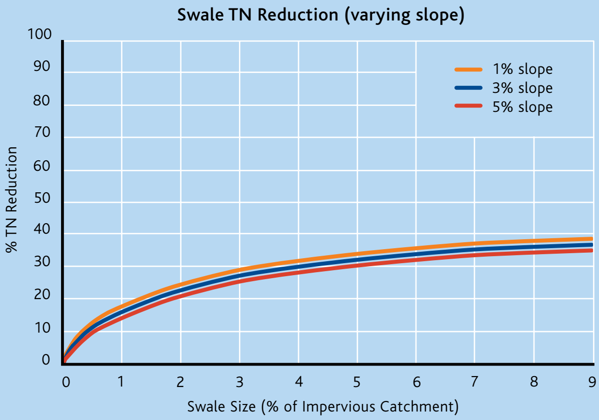


Figure 2. TN reduction by a swale in Melbourne as slope varies (0.25m vegetation height)



Buffer strips

Buffer strips aim to provide discontinuity between impervious surfaces and the drainage system. The key to their operation, like swales, is an even shallow flow over a wide vegetated area. Buffers are commonly used as a pre-treatment for other stormwater measures.

Set downs

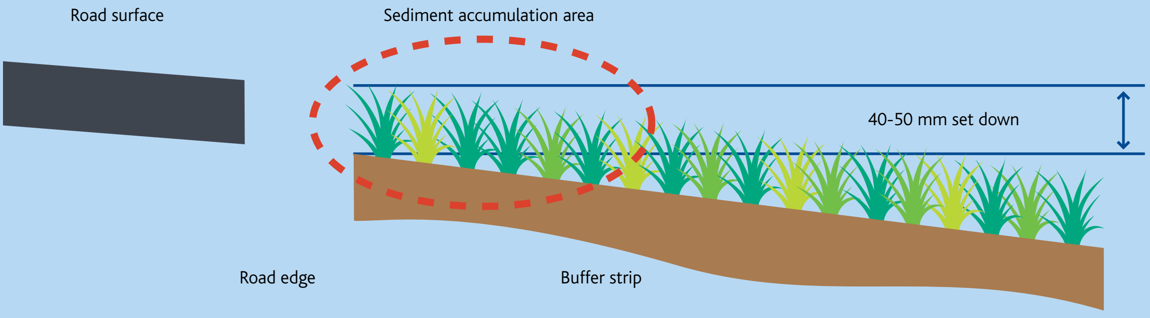
Set down buffer strips from the road surface to:

- Account for sediment accumulation over time
- Allow for the height of the grass (once grown) to be slightly set down from the road level.

The required set down is a trade off between creating scour from runoff and providing sufficient build up space for accumulated sediment. Generally between 40 and 50 mm set down from the paved surface will be adequate with a pavement surface that is tapered down towards the buffer strip (as illustrated in Figure 3).

For detailed information, refer to Chapter 8 of Melbourne Water's Technical manual *WSUD Engineering Procedures: Stormwater* (2005).

Figure 3 Typical buffer strip arrangement



Maintenance

Maintenance costs tend to be higher in the first five years, while the swale or buffer is becoming established.

- Grassed swales cost about \$2.50 to \$3.13/m^2/year for the establishment period (approximately five years) – but if residents mow regularly, there is less cost to local authorities
- Vegetated swales cost about \$9/m^2/year, ongoing.

After five years, the cost for grass swales decreases to roughly \$0.75—\$1.50/m^2/year[36].

For a maintenance checklist, refer to the WSUD Engineering Procedures for Stormwater Manual[37].

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[36] EPA 2008, *Maintaining water sensitive urban design elements*, publication 1226

[37] *WSUD Engineering Procedures: Stormwater*, CSIRO 2005.

Fact Sheet 13: **Raingardens**

Small	Medium	Large	Broad
●	●	●	●

In raingardens, stormwater runoff is filtered through a vegetated sand media layer. It's then collected through perforated pipes so it can flow to downstream waterways or into storage for reuse. Temporary ponding above the sand media provides additional treatment.

Raingardens are not intended to be infiltration systems as the dominant path for water is not discharge into groundwater. Any loss in runoff is mainly attributed to maintaining filter media moisture (which is also the vegetation's growing media).

Vegetation

Vegetation that grows in the filter media enhances its function by:

- Preventing erosion of the filter medium
- Taking up nutrients and water
- Continuously breaking up the media through plant growth to prevent clogging of the system
- Providing biofilms on plant roots onto which pollutants can adsorb.

Filtration media

Selection of an appropriate filtration media is a key issue that involves a trade-off between providing sufficient:

- Hydraulic conductivity (i.e. passing water through the filtration media as quickly as possible)
- Water retention to support vegetation growth (i.e. retaining sufficient moisture by having low hydraulic conductivities) and remove pollutants.

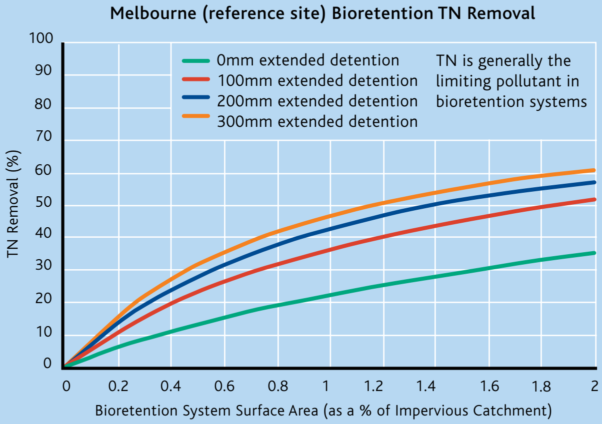
Typically a sandy type material with a hydraulic conductivity of 100-300mm/hr is suitable. However media can be tailored to a vegetation type.

Pollutant removal and sizing curves

Raingardens are typically limited in their ability to reduce Total Nitrogen (TN). Figure 1 shows a design curve for preliminary sizing of rain gardens in Melbourne, relating typical performance to a percentage of the impervious catchment. Best practice targets are the removal of:

- 45% TN
- 45% Total Phosphorus (TP)
- 80% Total Suspended Solids (TSS).

Figure 1: TN removal by Raingardens in Melbourne



Raingarden basins

The treatment process in rain garden basins uses physical filtration of sediments through the filter media and the removal of nutrients through the biological and chemical interactions, primarily again in the filter media.

Typically, flood flows bypass the basin, preventing high flow velocities that can dislodge collected pollutants or scour out media or vegetation.

These devices can be installed at various scales. For example:

- Planter boxes
- Retarding basins
- Streetscapes integrated with traffic calming measures.

Fact Sheet 13: **Raingardens**

Raingarden swales

Swale raingardens (refer to Figures 2 and 3) provide both stormwater treatment and conveyance functions.

A raingarden is installed in the swale's base. The swale component provides stormwater pre-treatment to remove coarse to medium sediments while the raingarden removes finer particulates and associated contaminants.

A raingarden 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 1-4% slopes. In steeper areas, check dams are required to reduce flow velocities. For milder slopes, it's important to ensure adequate drainage is provided to avoid nuisance ponding (a raingarden along the full length of the swale will provide this drainage).

Runoff can be directed into raingarden swales either through direct surface runoff (e.g. with flush kerbs) or from an outlet of a pipe system.

Figure 2: Typical swale raingarden – section drawing

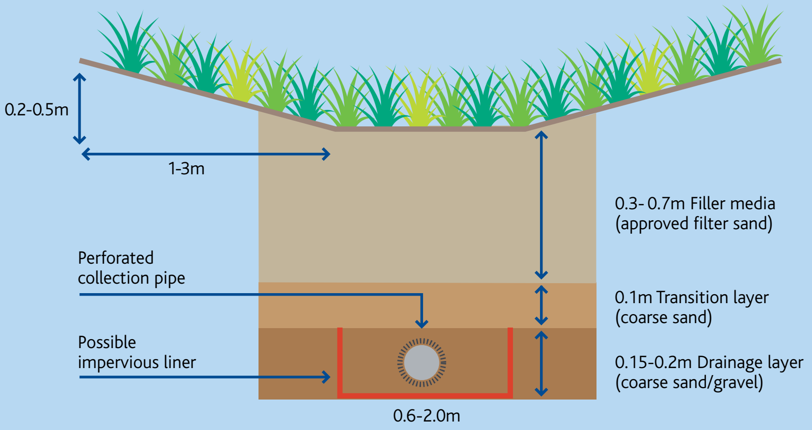
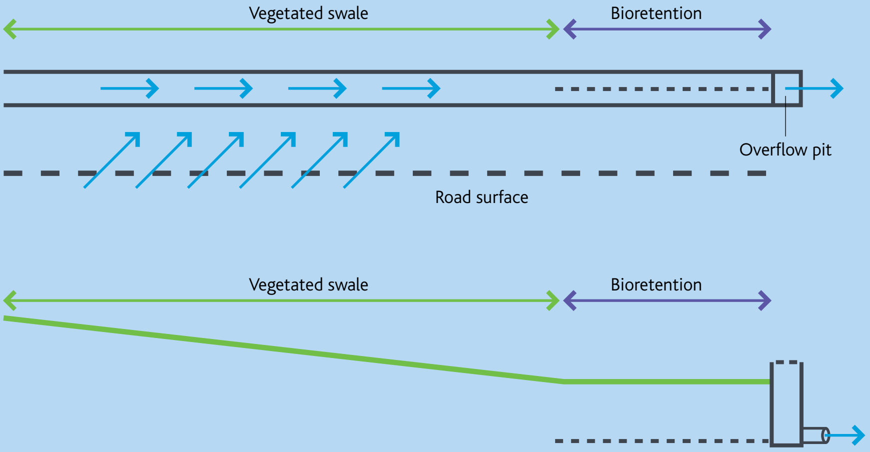


Figure 3: typical swale raingarden system adjacent to roadside – plan and section drawing



Maintenance

The typical annual maintenance cost for a raingarden is approximately 5-7% of the construction cost. Maintenance costs are likely to be higher in the first few years due to the more intensive effort needed to establish the system.

The maintenance cost for mature raingardens are:

- \$2.50/m^2 for grassed systems
- \$9/m^2 for vegetated systems using native vegetation[38].

For a maintenance checklist, refer to the *WSUD Engineering Procedures for Stormwater Manual*[39].

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[38] EPA 2008, *Maintaining water sensitive urban design elements*, publication 1226

[39] *WSUD Engineering Procedures: Stormwater*, CSIRO 2005.

Fact Sheet 14: **Raingarden tree pit**

Small	Medium	Large	Broad
	●	●	●

Raingarden tree pits are one option for stormwater treatment. They can be configured to suit landscape and streetscape design even when it's highly urbanised, or where grades are steeper than 4%. Below, Figure 1 shows some examples.

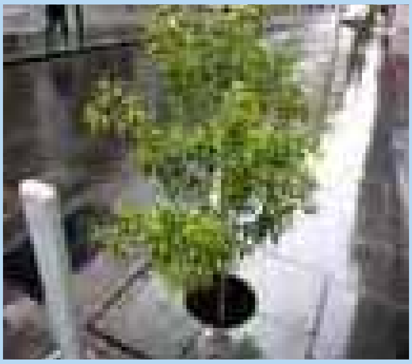
Street trees can be designed to incorporate a raingarden stormwater treatment where street runoff is diverted to a street tree pit. The street tree is lowered to allow stormwater runoff to enter the tree pit and filter through the vegetated media before being discharged into the stormwater system.

Figure 1. Examples of raingarden tree pits, configured in different landscape finishes

Cremorne St, Richmond (VIC)

Marwal Ave, North Balwyn (VIC)

Batman Ave, Docklands (VIC)



Little Collins St, Melbourne (VIC)

Design considerations

Raingarden tree pits have similar design and operational principles as other raingardens. The key differences are:

- Vegetation selection (i.e. the tree species)
- Smaller footprint
- Structural soil properties (media)
- Landscape finishes.

Built environment

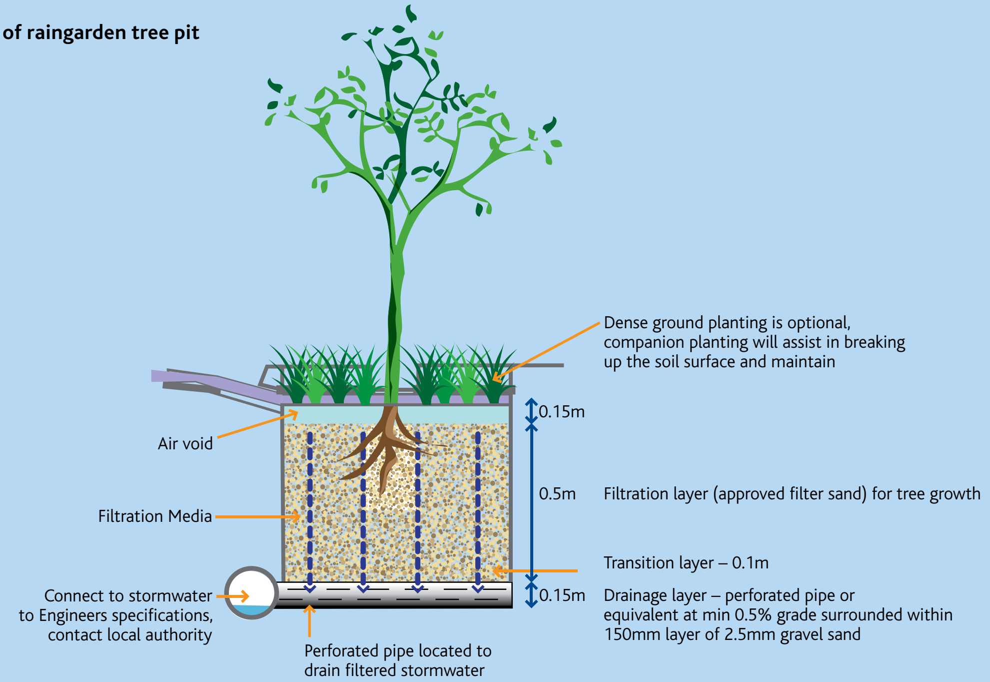
For retrofit sites, the interaction with existing built environment is an important design and implementation consideration. In high density urban areas, such as Melbourne, there is a high competition for open and underground space.

A typical raingarden tree pit

Figure 2 shows a diagram of a typical raingarden tree pit. Raingarden tree pits work like raingarden basins. The tree pit filters stormwater runoff through the vegetated filter media. Temporary ponding above the filter media provides additional treatment within a small space. An extended detention depth is needed. Importantly for rain garden tree pits, the tree must be set down, typically below the invert of the kerb.

Fact Sheet 14: **Raingarden tree pit**

Figure 2. Diagram of raingarden tree pit – cross section



Key design issues

Tree media surface layer

The top of tree media surface layer should be set a minimum of 50mm below the invert of the slot cut in the kerb and channel. This allows for the extended detention depth around the tree.

Infrastructure interface

Consider the relationship with surrounding infrastructure including:

- Road surface grading (selection of either single cross fall or crowned road)
- Location of street trees to integrate with existing stormwater infrastructure, in particular:
  - location of stormwater pits
  - levels at the road surface
  - levels for the stormwater lines that will receive treated water from street tree drainage.
- Identification and location of existing services, for example:
  - gas
  - electricity (underground and above ground)
  - telecommunication
  - water
  - sewerage.

Stormwater catchment area

Identify the stormwater catchment area that will be directed to the street trees. This includes downpipes from adjacent buildings discharging to kerb and gutter drainage.

Inlet design

Design the inlet so it operates appropriately in relation to:

- Receiving stormwater
- Velocity control and sedimentation issues
- Maintenance implication (including street cleaning)
- Pre-treatment requirements (litter and sediment capture).

High flow events

High flow bypass is needed to make sure high flow events are safely conveyed to the conventional drainage system. Typically this is provided by side entry pits located downstream of inlets to the raingarden tree pits.

Fact Sheet 14: **Raingarden tree pit**

Underdrainage

Typically a perforated pipe is incorporated into the design to provide underdrainage. The underdrainage is connected to the conventional drainage system. This ensures treated stormwater is conveyed to the receiving waterways and prevents water logging the tree. One end of the underdrainage is exposed to allow periodic flushing, if required.

Selection of tree species

Use expert advice to assess the suitability of tree species to the raingarden tree pits. Suitability depends on:

- Root structure
- Climatic condition
- Interaction with surrounding infrastructure.

The selection of the tree species requires consultation between the landscape architect, arborist and WSUD specialist.

Filter media specifications

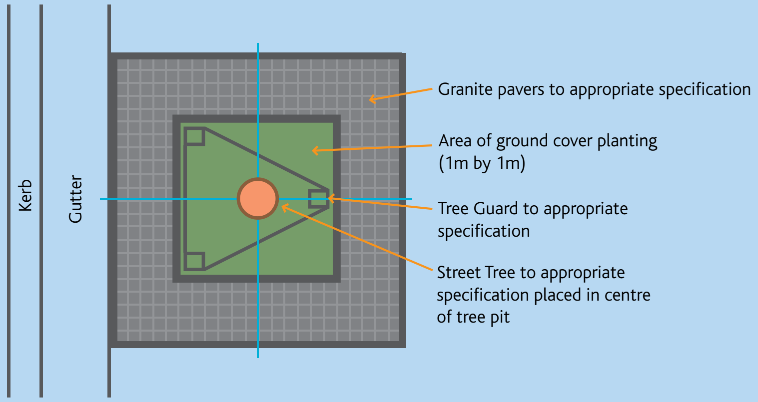
Consult media specifications to get the desired performance and structural conditions (see *WSUD Engineering Procedures: Stormwater*, Melbourne Water pp 89-90). A hydraulic conductivity of 100-300[40] mm/hr is typically recommended for street tree bioretention pits (this normally reduces with time to a minimum 50-100mm/hr).

Basin configuration

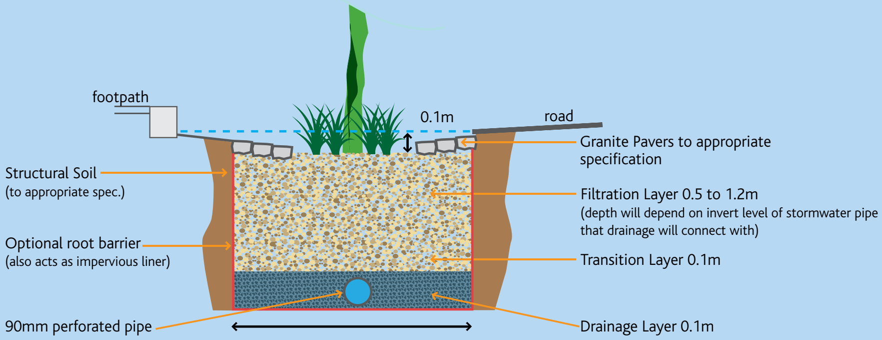
Raingarden tree pits can be configured in a basin. This involves setting down of the tree and integrating the surface with the surrounding street level. An example of a raingarden tree pit integrated into the streetscape is shown in Figure 3 below.

Figure 3. Raingarden tree pit integrated into the streetscape – situated roadside of kerb

a. Plan section



b. Cross section



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[40] As per FAWB filter media guidelines revised March 2008.

Fact Sheet 14: **Raingarden tree pit**

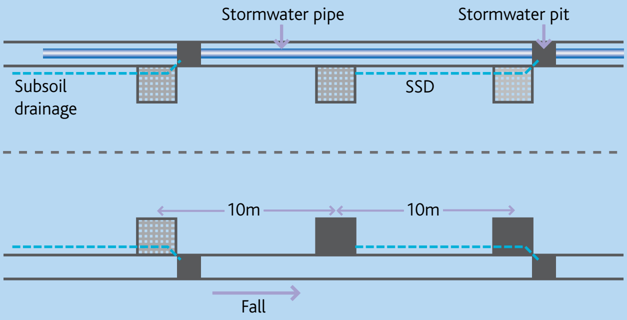
Treatment size

The design curves for raingardens are also used to size raingarden tree pits. The catchment is defined by the impervious surface area draining to each raingarden tree pit.

The typical road runoff catchment area is small for an individual raingarden tree pit. The street trees are spaced at a high frequency, so they have sufficient treatment for their catchment.

A typical street layout is shown in Figure 4 below.

Figure 4. Typical street layout for raingarden tree pit – roadside of the kerb



Safety considerations

Raingarden tree pits must be set below the kerb invert and the design must also integrates pedestrian safety. Examples of designs incorporating safety measures include:

- Concealment of extended detention depth with frame (e.g. Little Collins St)
- Integration of landscape design with retaining wall (e.g. Batman Drive)
- Use of pebble mulch (e.g. Batman Drive & Martin St)
- Installation of a hand rail (e.g. Cremorne St).

Openings in pit lids around tree trunks must not be less than 0.75m in diameter. Grates should be provided over the openings to prevent human injury. Concentric rings can be used and cut out sequentially to provide more room as the tree grows.

Street sweeping

Regular maintenance regimes are essential to remove gross pollutants. Therefore street sweeper access is required, particularly for designs which incorporate kerb outstand. Sharp curves should be avoided, as they can collect gross pollutants.

Maintenance

Raingarden tree pits are designed for minimal maintenance. Street sweeper access is needed to clean litter from the inlet and enable stormwater to runoff to the tree.

The typical annual maintenance cost of a tree pit is 5-7% of the total construction costs[41].

Covering the tree pit will prevent litter accumulation. Periodic cleaning will be needed and depends on the design of the tree pit cover and location of the street tree.

Raingarden tree pits are designed to collect sediments and nutrients from the stormwater runoff. Over a long period of time (greater than 30 years) these sediments will accumulate, particularly in the top filter layer (200-300mm). The top layer of the media will require replacement and hence also involves replanting the tree. The top filter media layer will require suitable disposal.

For a maintenance checklist, refer to the *WSUD Engineering Procedures: Stormwater manual*[42].

Protection during the build out phase

Excessive sediment load, for example during construction phases, will cause the raingarden tree pit filter media to clog. Best practice site management during construction is required to minimise sediment load. During the construction phase, the raingarden tree pit can be protected by a geotextile layer. This is placed on top of the filter media and then covered by turf. At the conclusion of the construction, the turf can be removed and tree planted. This enables the infrastructure to be constructed during the build out phase, yet the media protected from excessive sediment loads.

[41] EPA 2008, *Maintaining water sensitive urban design elements*, publication 1226.

[42] *WUSD Engineering Procedures: Stormwater*, CISRO 2005.

Fact Sheet 15: **Surface wetlands**

Small	Medium	Large	Broad
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Constructed surface wetland systems use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. They generally consist of an inlet zone (a sediment basin to remove coarse sediments – see Fact Sheet 9 Sedimentation (settling)), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone).

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. While wetlands can play an important role in stormwater treatment, they can also have significant community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and resting areas. They can also improve the aesthetics and form a central landscape feature.

Wetland systems provide flood protection when incorporated into retarding basins. Additionally an open water body or pond at the downstream end of a wetland can provide water storage for reuse, such as irrigation. Wetlands can be constructed on many scales, from small house blocks (pictured left) to large regional systems. In highly urban areas they can have a hard edge form and be part of a streetscape or building forecourts. In regional settings they can be over 10 hectares in size and provide significant habitat for wildlife.

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.

The inlet zone reduces flow velocities and encourages settling of sediments from the water column. They can drain during periods without rainfall and then fill during runoff events. They are sized according to the design storm discharge and the target particle size for trapping. Sediment basin maintenance is usually required every two to five years. Sediment basins should be designed to retain coarse sediments only (recommended particle size is greater than 0.125mm). The highest contaminant concentrations are associated with fine sediments and therefore waste disposal costs for this material can be much higher.

Macrophyte zone

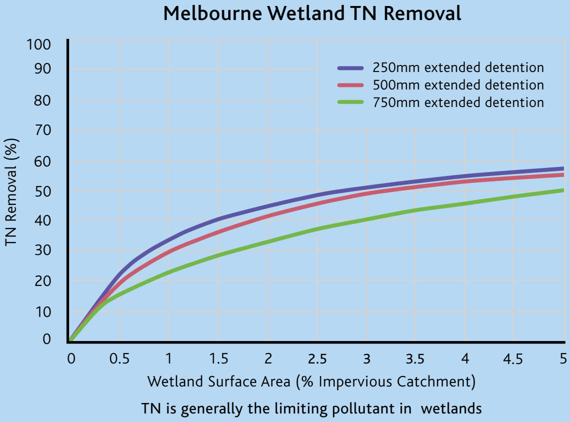
An important operating characteristic of macrophyte zones is even, well distributed flows, that pass through various bands of vegetation. Strong vegetation growth is required to perform the filtration process as well as withstand flows through the system. Vegetation selection is heavily dependant on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

Different zones in a macrophyte system perform different functions. Ephemeral areas are often used as organic matter traps. These areas wet and dry regularly and thus enhance the breakdown process of organic vegetation. Marsh areas promote epiphyte (biofilms) growth and filtration of runoff. Epiphytes use the plants as substrate and can effectively promote adhesion of fine colloidal particulates to wetland vegetation and the 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, as well as providing greater aesthetic appeal.

Optimal detention times in the wetland (typically 72 hours – 12 in the inlet zone and 60 in the macrophyte zone) ensure desired performance. The macrophyte zone outlet must 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 1, with TN the limiting design parameter. For a desired performance (typically 45% TN reduction), the required wetland surface area is calculated as a percentage of the impervious catchment area to be treated.

Fact Sheet 15: **Surface wetlands**

Figure 1 Sizing curve for wetlands in Melbourne



TN is generally the limiting pollutant in wetlands

Maintenance

To cost wetlands, the treatment device includes an inlet zone sediment basin/ pond and macrophyte zone, without a gross pollutant trap. Wetlands typically cost between two and six per cent of the construction cost to maintain each year. Generally, there is a very strong correlation between typical annual maintenance costs and the surface area of the wetland. Smaller wetlands are cheaper to maintain. Maintenance costs increase where there are:[43]

- Introduced aquatic weeds
- Sediments are contaminated
- Upstream control of sediment is poor
- Access is difficult
- Dewatering areas are limited.

For a maintenance checklist and more information on wetland design, refer to the *WSUD Engineering Procedures: Stormwater manual*[44].

[43] EPA 2008, *Maintaining water sensitive urban design elements*, publication 1226.

[44] *WUSD Engineering Procedures: Stormwater*, CISRO 2005.

Fact Sheet 16: **Subsurface flow wetlands**

Small	Medium	Large	Broad
	?	•	•

Wetlands are a complex assemblage of:

- Water
- Soils
- Microbes
- Plants
- Organic debris
- Invertebrates.

Subsurface wetlands are a proven technology to adequately remove organic matter and suspended solids. Subsurface flow wetlands provide a low cost, very low energy, natural treatment system.

Subsurface wetlands and surface wetlands

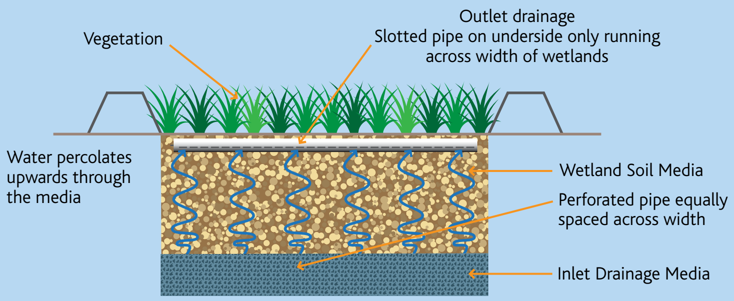
Subsurface wetlands are typically applied in wastewater treatment systems where there is a relatively consistent influent flow rate. In comparison, surface wetlands used to treat stormwater flows must be able to cope with variations in flows as a results of rainfall patterns.

Soil substrata

In subsurface flow wetlands, all the flow is through the soil substrata (refer to Figure 1). 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, biological oxygen demand (BOD) and total suspended solids (TSS) are mainly removed by biological decomposition.

Figure 1 Typical subsurface flow wetland – section drawing



Treatment of greywater and blackwater

Subsurface wetlands are a proven technology to adequately remove organic matter and suspended solids from greywater and blackwater. Subsurface wetlands provide a good quality effluent with typical average effluent BOD and TSS less than 20 mg/l. They are commonly used in Europe to treat greywater in high density developments.

Subsurface wetlands have also been used in Australia to treat greywater from colleges and buildings at Charles Sturt University. In Melbourne, a subsurface wetland treats laundry water from the Department of Human Services Artherton Gardens housing estate. The water is then used to drip irrigate the surrounding reserves garden beds.

Pollutant removal

Subsurface wetlands are effective in the removal of nitrogen. The environment within a subsurface wetland is mostly anoxic or anaerobic. Some oxygen is supplied to the roots – which is likely to be used up in the bio mass growth, rather than penetrate too far into the water column.

Fact Sheet 16: **Subsurface flow wetlands**

Design

Primary design criteria for subsurface flow wetlands are as follows:

- Detention time
- Media size
- Hydraulic loading rate
- Organic loading rate
- Bed depth
- Aspect ratio.

Subsurface wetlands typically form a component of the landscape on the site and form an integral part of the aesthetics of a residential development.

Blockage of inlet zones

A frequently reported problem with subsurface wetlands is the blockage of the inlet zones. This leads to short circuiting and surface flow. Attention must be given to good inflow distribution and the placement of larger aggregate within this inlet zone. Inlet apertures must be large enough to avoid being blocked by algal growth.

Typical sizing

A rule of thumb sizing for wetlands is 1-2m^2 of surface area per person. Design is dependent on water quality, specifically BOD concentration. Depths of sub-surface flow wetlands are typically half a metre but no more than 0.6 m.

Typical cost

Typical costs for a wetland to treat greywater for 500 people are $100,000 to $150,000. However costs will vary depending on the actual site.

Maintenance

Subsurface flow wetlands need routine operation and maintenance. Maintenance procedures include:

- Routine monitoring of the distribution and collection systems
- Removal of settled sludge from the pre-treatment tank.

Dead plant material does not need to be removed from the wetland, however routine weeding of the wetland system is required.

For a maintenance checklist, refer to the *WSUD Engineering Procedures: Stormwater Manual*[45].

Further information

The CERES biofilter uses a reed bed to treat its wastewater. For more information about the CERES biofilter, visit the CERES website at www.ceres.org.au.

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

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[45] *WUSD Engineering Procedures: Stormwater*, CISRO 2005.

Fact Sheet 17: **Suspended growth biological processes**

Small	Medium	Large	Broad
?	•	•	•

Biological treatment is engineered to accelerate natural biological processes and efficiently remove soluble and some insoluble pollutants from water.

Suspended growth systems have micro-organisms freely suspended in water. They are mainly designed to:
- Oxidise both organic and ammonium nitrogen (to nitrate nitrogen)
- Decrease suspended solids concentrations
- Reduce pathogen concentrations.

Two examples of suspended growth system are described below:
- Activated sludge process
- Membrane bioreactor.

Activated sludge process

Activated sludge is a suspension of micro-organisms in water. The micro-organisms are activated by air that provides oxygen. The activated sludge process is typically continuous-flow with aerobic suspended-growth. This process is suited to blackwater treatment due to the high organic concentration and the minimum nutrient level required for optimal performance.

Usually there are two distinct phases and vessels in the process: aeration followed by settling.

The process maintains a high population of micro-organisms (biomass) by recycling settled biomass back into the treatment. There are two main mechanisms that remove organics:
- Biomass oxidises and synthesizes the soluble and colloidal organic matter into cell mass and metabolic materials
- Suspended organics are flocculated with biomass and settle.

Aeration

Aeration is typically supplied by air and dispersed through the reactor. This is essential to encourage metabolism and enhance mixing.

By-products formed are:
- Substrate removal and growth
- Products of microbial maintenance and cell lysis.

Treatment efficiency can be assessed by comparing total BOD (biological oxygen demand) to soluble BOD (or COD).

Settling

Natural flocculation and biomass settling characteristics will separate sludge in a sedimentation device, typically a clarifier or sediment basin. Recycling a portion of the sludge to the aeration basin is essential to maintain a healthy biomass 'stock'. Processing and disposal of the relatively large sludge must be considered in the design and operation.

The mixing regime within the reactor is critical for optimal performance. Reactors can either be a well-mixed or plug flow reactor. The retention time influences food to micro-organism ratio sludge age. Increased sludge age causes endogenous decay.

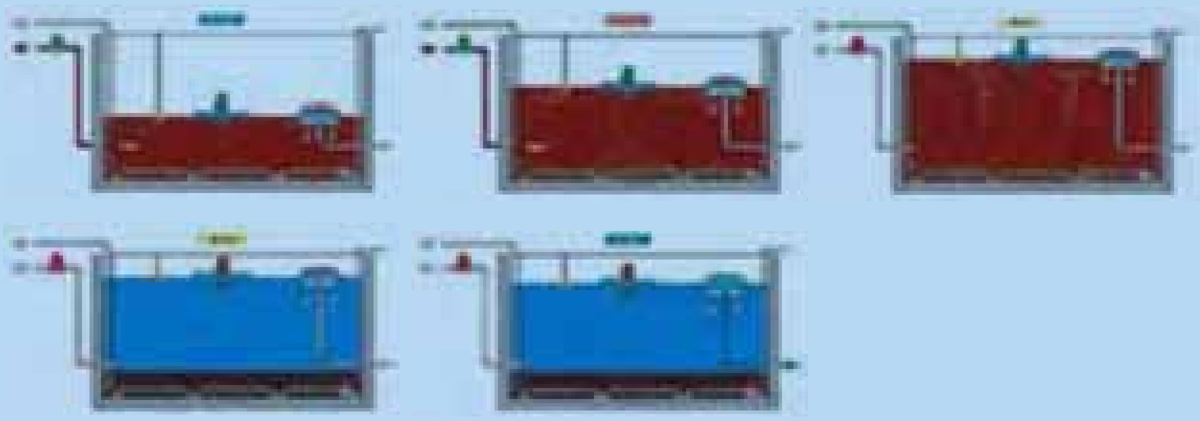
Sequencing batch reactor (SBR)

A sequencing batch reactor (SBR) is an activated sludge process where all the main treatment steps occur in the same reactor (Figure 1). There is a sequence of:
- Filling with influent
- Reaction (usually with aeration)
- Settling
- Drawing and decanting
- Remaining idle.

The fill time depends on the reactor volume. Operation, specifically the aeration and idle times, relies on the anoxic or anaerobic fill period. A continuous flow reactor that fills and withdraws during the cycle is a variation on this true batch reactor.

Fact Sheet 17: **Suspended growth biological processes**

Figure 1 Schematic of SBR system



Treatment variations

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

Powdered activated carbon activated sludge processes:

- Add activated carbon to enhance treatment, particularly by adsorption
- 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 (kilolitres per day) an area of 20m² is typically required. As a rule of thumb the footprint for a suspended growth system is about 0.1m²/person.

Maintenance

All mechanical inputs will need regular maintenance. De-sludging of the reactor vessels will also be periodically required. Operation costs include pump and energy costs to operate the aerator.

Typical cost

A complete suspended growth system typically costs $150,000-200,000.

Membrane Bioreactor (MBR)

A membrane bioreactor (MBR) combines the process of a biological reactor and a membrane filtration system into one process. MBRs that combine filtration and biological treatment in one system:

- Require a small amount of space
- Replace the need for a separate filtration process
- Provide very high quality effluent with low TSS, BOD, and turbidity.
- Will meet almost all health criteria guidelines.

Configuration

There are two basic configurations for a MBR:

- Submerged integrated bioreactor that immerses the membrane within the activated sludge reactor
- Bioreactor with an external membrane unit.

Usage

MBRs provide proven and reliable treatment technology. They have been used extensively in Japan for greywater and blackwater reuse systems. These are relatively new processes in Australia, with the grey water system at DHS 2 Apartment Block in Windsor being one of the first commercial units to get approval in Melbourne.

Maintenance

The use life of the membrane is an issue with this method, due to the replacement cost of the membrane. In some cases, operating experiences have shown membranes need to be replaced every two years, as opposed to the design period of five years.

Control of membrane fouling is an important operational issue. If fouling is not controlled, membranes will wear more quickly and there will be increased energy costs and a decrease in effluent quality.

Typical sizing

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

Typical cost

A 100kL/day plant typically costs $400,000 with operating costs for maintenance and membrane replacement approximately $25,000 per year. MBRs have higher capital and energy costs than other treatment systems.

Suppliers

There are a range of suppliers of MBRs including:

- Environmental Solutions International – www.environ.com.au/ (Supplier of Kubota MBR's)
- 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).
- Clearwater – Aquacell.

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 a highly urbanised built environment. However, there are other technologies, such as anaerobic digesters suitable for high organic loads, which may be also suitable in certain applications.

Related site include:

- 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 18: **Fixed growth biological processes**

Small	Medium	Large	Broad
?	•	•	•

Biological treatment involves natural processes to breakdown high nutrient and organic loading in water. Biological treatment systems are usually used to remove dissolved and colloidal organic matter from water.

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 discussed in this fact sheet include:
- Trickling filters
- Rotating biological contactors
- 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 is attached to the media surface
- Oxygen is provided by natural or forced aeration through the media
- Soluble organic matter is transported to the biological film
- Biofilm attached to the porous media metabolise the soluble and colloidal organic matter
- Organic content is reduced and the water treated.

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 metabolism.

A highly diverse microflora populate a trickling filter, with bacteria the main microbial group. Synthetic media can be used for efficient biofilm growth. However it’s expensive, and typically rock or plastic pieces are used. The void space enables aerobic growth, as the trickling water naturally aerates as it passes over the media.

Sizing

Fixed growth biological systems are small and compact. They require a footprint of approximately 30-40m^2 to treat a flow of 20 kl/day, with a minimum height of 2m. They are suitable for locating in a basement, but require adequate ventilation.

Maintenance

Maintenance requirements show that approximately 2-3 hours are required each month, with an annual maintenance check of 6-8 hours. Generally fixed growth systems are self cleaning on a day-to-day basis and alarms can be connected to telemetry systems.

Typical cost

A complete fixed growth system typically costs $150,000-200,000.

After treatment, the biomass (combination of the biological products) can be separated by settling in a lagoon or wetland. Filtration is not a significant removal mechanism in this biological process.

Variations on 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)

A rotating biological contactor (RBC) is a modified form of a trickling filter. It uses rotating discs to support active biofilm growth. This biofilm metabolises and therefore removes organic material from the wastewater.

RBCs are available in ‘package treatment plants’ which make installation and operation easier. These plants contain:
- A primary sedimentation tank
- The biological chamber
- A secondary clarifier
- 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. Typically 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. Sedimentation (typically clarification) is needed to remove the biomass and suspended solids.

Fact Sheet 18: **Fixed growth biological processes**

Typical sizing

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

Typical sizing

Trickling Filters are available in small package plants. To treat flows of 20 kL/day, an RTF requires 15-20m^2 with a hydraulic loading of 100 to 180 cm/day. This compares to an RSF requiring a 100m^2 area with a hydraulic loading of 20 to 30 cm/day.

Typical cost

These systems typically cost $100,000-200,000 for a complete re-circulating filter system.

Suppliers

There are a number of suppliers of RBC and trickling filter package treatment plants in Australia. Further information about specific systems can be obtained from the following suppliers:

- EPCO Australia – www.epco.com.au
- Water Recycled Group – www.waterrecycle.com.au (slightly 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
- Maintaining and replacing the filter surface as necessary
- Flushing the distribution system manually.

Further information is available from Innoflow technologies – www.innoflow.co.nz(Australian and NZ Supplier of Orenco Systems).

Fact Sheet 19: **Recirculating media filters**

Small	Medium	Large	Broad
?	●	●	

Recirculating textile filters (RTF) and recirculating sand filters (RSF) are both biological treatment processes removing organic material from wastewater. The main difference between filter types is the filtration media, namely textile or sand.

Recirculating textile filters are similar in nature to trickle filters, however the media used for the growth of biofilms are textiles rather than plastics or rocks. RTFs are available in small compact package plants, suitable for decentralised treatment.

Key components

The RTF and RSF consist of two major components:

- Biological chamber and low pressure distribution system
- Recirculating tank and pump.

A biological chamber and low pressure distribution system has wastewater flowing between and through the non-woven light-weight textile material in the RTF and through a bed of sand in the RSF.

A recirculating tank and pump pumps typically 80% of the filtrate 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.

Packaged systems

The recirculating filters are packaged systems consisting of:

- The media
- The container
- The distribution system
- Recirculating tanks and pumps
- A telemetry system for external monitoring.

Suitable uses

Recirculating filters (RFs) can provide a reliable low maintenance treatment system for decentralised wastewater systems. RFs can also provide high quality effluent of less than 10 mg/l Biological Oxygen Demand (BOD) and total suspended solids (TSS). 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. In this case, no recirculation tank or pump is required. A larger filter is required for equivalent performance. The application of RFs to the treatment of greywater in high density applications is not well studied. However results from single dwelling lots show good results.

Maintenance

Recirculating filters require routine maintenance systems. Maintenance requirements are typically low and are not complex.

Maintenance should include:

- Monitoring the distribution system to the filter
- Maintaining and replacing the filter surface as necessary
- Flushing the distribution system manually.

Typical sizing

RTFs are available in small package plants. To treat flows of 20 kL/day, an RTF requires 15-20m2 with a hydraulic loading of 100 to 180 cm/day. This compares to an RSF requiring a 100m2 area with a hydraulic loading of 20 to 30 cm/day.

Typical cost

These systems typically cost $100,000-200,000 for a complete re-circulating filter system.

Suppliers

Further information is available from Innoflow technologies – www.innoflow.co.nz(Australian and NZ Supplier of Orenco Systems).

Fact Sheet 20: **Sand and depth filtration**

Small	Medium	Large	Broad
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Filtration types

Filtration is a tertiary treatment process that typically occurs after the secondary biological process. Filtration may be required to remove residual suspended solids and organic matter for more effective disinfection.

Filters have been used for water treatment for over 100 years. There are two major types of filters:

- Sand and depth filtration
- Membrane filtration.

This fact sheet discusses sand and depth filtration. Membrane filtration is discussed in *Fact Sheet 21: Membrane filtration*.

Sand filtration

Sand (or other media) filters typically treat settled wastewater effluent. For onsite 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.

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

Pollutant removal

Water is applied to the top of the filter and allowed to percolate through the media. With time, the headloss builds up and the filter media has to be cleaned by backwashing. The principal removal mechanism is by straining:

- Particles larger than the pore space are strained out
- Smaller particles are trapped within the filter by chance.

The hydraulic flow rate determines 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 be decomposed during low dose periods.

Typically a biofilm forms on upper layers. This layer assists in the adsorption of colloidal pollutants and encourages oxidation of the organic material.

Flow

For effective microbial control, low flow is desired through the sand filter. This ensures contact between the sand media's biofilm and water. During low flow, the interstitial spaces between the sand granules enable oxygen to diffuse to the biofilm and encourage oxidation of organic material.

Design

There are a number of different designs for sand filters. Decisions are based on questions such as:

- What is the type of media?
- Does the operation needs to be taken off line to be backwashed?
- Is the flow up or down through the sand filter?

Key design considerations include:

- Type and size of filter media
- Filter bed depth
- Hydraulic loading rate
- Dosing frequency and duration
- Organic loading rate

Maintenance

Maintenance must:

- Ensure no build up of oil and grease on the filter media
- Ensure no agglomeration of biological flocs, dirt and filter media into mudballs which cannot be effectively backwashed
- Control loss of filter media.

Typical cost

A simple sand filter product with a small footprint can be provided as a package system. For example Aquatec Maxcon provide a small footprint pressure sand filter for approximately $20,000. These systems have an automatic backwash system built in which is controlled by headloss or effluent quality.

It may also be possible to adapt cheaper pool filters ($1000) used for filtering swimming pool and spa water to the purpose of 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. Usually there are four layers of filter media.

The particle size decreases through the filter's layers. The coarser top layer removes larger particles and finer material is removed towards the lower layers.

Pollutants are filtered throughout the bed and increase the overall filter efficiency (compared to a conventional sand filter).

Maintenance and design considerations are similar to sand filtration.

Fact Sheet 21: **Membrane filtration**

Small	Medium	Large	Broad
?	•	•	•

Filtration types

Filtration is a tertiary treatment process that typically occurs after the secondary biological process. Filtration may be required to remove residual suspended solids and organic matter for more effective disinfection.

Filters have been used for water treatment for over 100 years. There are two major types of filters:
- Sand and depth filtration
- Membrane filtration.

This fact sheet discusses membrane filtration. Sand and depth filtration is discussed in *Fact Sheet 20: Sand and depth filtration*.

Membrane filtration

Membrane (or cross flow membrane) filtration is a physical separation process used to filter pollutants using a semi-permeable media.

As water is passed 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
- A waste stream.

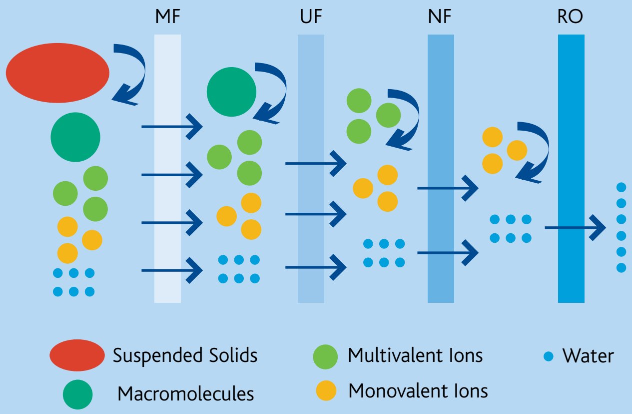
Pore size, pressure and pollutant removal

Membrane filtration processes can remove particles, bacteria, other micro-organisms, particulate matter, natural organic matter (NOM) and salt (desalination). The pore size of the membrane determines the removal of the pollutant (as shown in Figure 1 below).

As pore size decreases, smaller pollutants can be removed and pressure requirements increase. Smaller pore size means greater pressure and therefore greater energy requirements for effective treatment.

There are four classes of filtration, listed below in decreasing order of pore size:
- Microfiltration (MF) – the largest pore size
- Ultra-filtration (UF)
- Nanofiltration (NF)
- Reverse osmosis (RO) – the smallest pore size.

Figure 1 Types of membranes and membrane selectivity (reproduced from Bhattacharjee et al (1999))



Fact Sheet 21: **Membrane filtration**

The pressure requirements, pore size and typical pollutant removal for each class are summarised in Table 1 below.

Table 1: Summary of membrane filtration key features

Filtration	Pore size	Operating pressure	Typical target pollutant
Micro filtration	0.03 to 10 microns	100-400kPa	Sand, silt, clays, Giardia lambia, Cryptosporidium.
Ultra filtration	0.002 to 0.1 microns	200-700kPa	As above plus some viruses (not an absolute micrins barrier). Some humic substances.
Nano filtration	Approximately 0.001 microns	6.00-1,000kPa	Virtually all cysts bacteria, viruses and humic materials.
Reverse osmosis	Approximately 4 to 8 AngStroms	300-6,000kPa (or 13,000kPa - 13.8 bar)	Nearly all inorganic contaminants Radium, natural organic substances, pesticides, cysts, bacteris and viruses. Salts (desalination)

Innovation and modular design

The continued innovation and modular design of membrane filtration processes is advantageous for small scale applications from an operational and economic perspective. Now membrane filtration systems are available in modular package treatment plants, well suited for sewer (water) mining, grey water treatment and groundwater treatment.

Selection

Choice of membrane process is influenced by:

- Desired water quality
- Water end use
- Pollutant size and type.

Maintenance

Membrane fouling is expected and occurs due to pollutant build-up on the membrane surface. Fouling is typically managed by a quick backwash system, integrated into the plant's operation. Periodically chemical cleaning is required to rejuvenate the membranes.

Membranes have a finite life and are typically replaced every two to five years.

Design

Membrane configuration will be determined by:

- Water quality
- Available space.

Pre-treatment may be needed to remove larger particles and natural organic impurities. This will improve the effectiveness of the process. UV disinfection after filtration is recommended for microbial control.

Waste disposal must be considered during design.

Optimal flow and pressure

Higher operating pressure increases permeate flow thereby increasing efficiency. However it also increases the fouling rate. Higher flow velocity across the membrane reduces the fouling. Therefore an optimal operating condition exists between flow and pressure.

Waste disposal stream

Adequate provision for the waste disposal stream is necessary. Membrane processes produce a waste stream, typically 15% of feed. However it can be as high as 50% in some RO operations. For sewer mining, the waste stream is typically directed back into the sewer.

Fact Sheet 21: **Membrane filtration**

Reverse osmosis

Reverse osmosis (RO) is the finest membrane filtration process with the smallest pore size, estimated to be around 4 to 8 Angstroms (about the size of a molecule). Therefore this process has the highest pressure requirements.

RO removes most pollutants including pathogens, viruses and salts. It's typically used for sewer mining or desalination. RO can separate ions (dissolved salt) from water and therefore produces very high quality water. Reverse osmosis units are particularly effective when used in a series configuration.

Pressure

A very high pressure (determined by the osmotic pressure and ionic concentration) is needed. This high pressure results in a high energy requirement.

Maintenance

The small pore size can be more readily blocked (or fouled) and therefore regular maintenance is required. Fouling can be managed by upstream water treatment such as sedimentation.

Chlorine concentration

RO membranes are typically constructed from cellulose acetate and polyamide polymers. Chlorine concentration has the potential to damage RO membranes. The cellulose acetate can tolerate chlorine levels used for microbial control whereas any chlorine present will destroy the polyamide polymers.

Typical costs

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 22: **Disinfection**

Small	Medium	Large	Broad
●	●	●	●

Disinfection minimises pathogenic micro-organisms which maintains public health. Pathogenic microorganisms in water are destroyed by disinfection. Eradicating waterborne pathogens is the most important public health concern for water treatment. Techniques for disinfection range from boiling water to large scale chemical treatment for water supplies. The three most common disinfection methods are:

- UV radiation
- Chlorination
- Ozonation.

UV disinfection

Ultraviolet (UV) disinfection uses UV light to deactivate microorganisms 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 therefore its ability to reproduce.

Advantages

UV disinfection is:

- Low-cost in terms of capital and operating costs
- Easy to install and operate
- Well-suited to small-scale water treatment processes.

UV offers a reliable, low maintenance disinfection system without the need to handle or store hazardous material. No chemicals are required and odour is minimal. This eliminates hazardous chemical handling and storage on site. Additionally no harmful by-products are formed. UV disinfection is a physical process. It's independent of pH and temperature has minimal impact.

Effectiveness

The effectiveness of UV disinfection depends on the quality and characteristics of the water, including:

- Intensity of UV radiation
- Amount of time exposed
- Reactor configuration
- Concentration of colloidal and particulate constituents (Turbidity).

UV radiation intensity depends on the radiation source, usually the distance between the lamp and the water. Reactor design should ensure uniform flow with maximal radial motion. This keeps the water flow well mixed and exposed to the UV radiation. In natural systems, 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 from colloidal and particulate constituents. Suspended solids reduce UV effectiveness by reducing transmission and shielding bacteria.

Maintenance

Cleaning is essential to ensure effective UV transmission. A maintenance programme 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 (Cl2), hypochlorous acid, or
- As hypochlorous salt (typically $Ca(OCl)_2$).

Chlorine addition requires chemical handling and storage. Byproducts of chlorination could be carcinogenic. There is particular concern and research needed to understand trihalomethanes (THM's). Chlorine provides residual microbial control, that is, it continues to disinfect water after it has passed through the treatment process. It's typically selected for potable water supply systems. The disadvantage of chlorinated water lies in the residual unpleasant taste and odour. Optimal chlorination dosage depends on the concentration and water pH and temperature. The pH level exerts a strong influence on the chlorination performance and should be regulated. Chlorination is the mix of chlorine dosing with ammonia for disinfection. It's designed to reduce by-product formation and reduce THM concentrations. Chloramines are longer lasting in water and provide a degree of residual protection.

Ozonation

Ozone is a more powerful oxidising agent than other disinfectants. Ozone is created by an electrical discharge in a gas containing oxygen. Therefore 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's impossible to maintain free ozone residuals in water for any significant time.

Further information

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

Part 5

Supporting Documents

Part 6

WSUD Glossary

Activated sludge process

An activated sludge process involves using naturally occurring micro-organisms to feed on the organic material in the sewage. Activated sludge is a rich mixture of bacteria and minerals. The process is used in sewage treatment plants to break down organic matter and nitrogen compounds. (Source MW).

Advanced sedimentation systems

Advanced sedimentation systems are devices that encourage physical separation such as clarifiers and can be incorporated into water treatment processes. They are typically a combination of mechanical and physical designs enhancing sedimentation.

Afforestation

Afforestation is achieved by planting trees or their seeds that convert open land into a forest. Afforestation can be carried out for a number of reasons including the creation of new forest habitats, as commercial forestry, or to create a carbon sink for the purposes of providing carbon offsetting activity.

Aerobic treatment

Biological process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth.

Algae

Algae are simple photosynthetic plants that live in water or moist places. (Source MW).

Anaerobic treatment

Reduction of the net energy level and change in chemical composition of organic matter caused by micro-organisms in an oxygen-free environment.

Algal Bloom

An algal bloom is a rapid increase in the mass of one or more algae, usually caused by a change in the flow, light, temperature or nutrient levels of the water in which it lives. (Source MW).

Biofilm

A biofilm is a concentration of micro-organisms on a surface that removes dissolved organic matter from water.

Bioretention systems

These are another name for raingardens.

Biological treatment

Biological treatment involves using natural processes to breakdown high nutrient and organic loading in water. There are two types of systems – fixed and suspended. Fixed growth refers to systems where micro-organisms are attached to a surface that is exposed to water. Suspended growth systems are where micro-organisms are freely suspended in water.

Biological uptake

Biological uptake is the transfer of a substance (typically nutrients) from water or soil to a living organism such as plants or micro-organisms (a biofilm).

Biological oxygen demand

Biological oxygen demand (BOD) is the decrease in oxygen content in a sample of water that is brought about by the bacterial breakdown of organic matter in the water. It is used as a water quality indicator.

Blackwater

Blackwater is wastewater that comes from a toilet or kitchen sink which is high in BOD, solids and oils and requires significant treatment.

Blue-green algae

Blue-green algae, or cyanobacteria, is one form of algae (see separate listing). Blooms of blue-green algae have occurred in some important Australian waterways during drought or because of severe pollution. (Source MW).

Buffer strip

Buffer strips are strips of vegetation planted to provide discontinuity between impervious surfaces and the drainage system.

Catchment

An area of land which drains all run-off water to the same lowest point such as a waterway.

City as a catchment

City as a Catchment' describes a catchment based approach to urban areas. The approach aims to sustainably manage the urban water cycle to minimise mains water consumption, reduce wastewater generation and lessen the impact of stormwater discharges on receiving waters.

Chlorination

Chlorination is a disinfection method used to kill pathogens using chlorine.

Climate sensitive

Carbon sensitive is used to mean that the greenhouse gas emissions from energy use, biodegradation processes and embodied energy emissions of equipment have been measured, reduced and offset over the operation of a water saving scheme.

Hence, although not all emissions associated with the water saving scheme have been neutralised, the additional emissions from the main sources have been reduced and offset.

Demand management

Demand management is an approach to reducing the consumption of water by reducing demand for it. Demand management includes educating people about how to save water, promoting the use of household and industrial appliances that use water more economically, such as dual-flush toilets, and putting a price on water that reminds people of its true value. (Source MW).

Desalination

Removal of salts from seawater or other saline (salty) solutions.

Detention time

Detention time is the time it takes for water to flow from the inlet to the outlet. Detention time is never a constant.

Dissolved air flotation

Dissolved air flotation (DAF) is a water treatment process that clarifies water by the removal of suspended matter such as oil or solids. The removal is achieved by dissolving air in the water under pressure and then releasing the air at atmospheric pressure in a flotation tank or basin. The released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface of the water where it may then be removed by a skimming device.

E. Coli

E. Coli is a faecal bacteria found in the digestive tract of animals, which are used to indicate presence of wastewater contamination within an environment.

Embodied energy

Embodied energy is the energy consumed by all the processes associated with the production of a product or material, from the acquisition of natural resources to product delivery.

Greenhouse gas emissions

Greenhouse gas emissions are gases emitted from the wastewater processes (methane) and the running of equipment that uses electricity to maintain a water project.

Hydraulic loading

Hydraulic loading is the flow of water to a treatment system. This is measured as the design flow divided by the plan area of the treatment measure and can be used to provide an indicative land requirement for a given treatment flow.

Hydrocyclone

Hydrocyclone is a device to clarify/separate or sort particles in a liquid suspension based on the specific gravity of the particles.

Greywater

Greywater is wastewater from the laundry and bathroom (but not the toilet). It usually contains soap, detergents and lint.

Gross pollutant trap

A gross pollutant trap (GPT) is a structure used to trap large pieces of debris (>5mm) transported through the stormwater system.

Life cycle assessment

Life-cycle assessments (LCAs) involve cradle-to-grave analyses of production systems or processes.

Life cycle costing

Life Cycle Costing (LCC) is a technique to establish the total cost of a project or service. It is a structured approach that addresses all the elements of this cost and can be used to produce a spend profile of the product or service over its anticipated life-span. The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options.

Land capability assessment

A land capability assessment is a survey that assesses the capability of a site to sustainably manage the health and environmental impacts of external stressors such as recycled water use. It looks at the distribution of land, contours or slope degree and direction, vegetation, water bodies including dams, drains, creeks, drainage depressions (transient wetlands) and bores.

Macrophyte

A macrophyte is a type of vegetation such as reeds used in surface wetlands. They are plants that grow in waterlogged conditions.

Mediafiltration

Mediafiltration is a physical treatment process that typically occurs after the secondary biological process. There are two major types of filters – sand and depth. Depth filters are a variation on a sand filter where a specified media is used to filter water. Typically there are more layers in a depth system.

Membrane bioreactor

A membrane bioreactor combines the process of a biological reactor, typically activated sludge, and a membrane filter system into one process.

Membrane filtration

Membrane filtration is a physical separation process to filter pollutants using a semi-permeable media. Water is passed through a membrane under pressure, it 'squeezes' through the structure. The membrane selectively traps larger pollutants. There are four classes of filter in order of particle size (micro, ultra, nano and reverse osmosis).

MUSIC

MUSIC is the acronym used for the Model for Urban Stormwater Improvement Conceptualisation software developed by the Cooperative Research Centre for Catchment Hydrology to model urban stormwater management schemes.

Nutrients

Nutrients are organic substances such as nitrogen or phosphorous in a water.

Ozonation

Ozonation is a powerful oxidising agent created by an electrical discharge in a gas containing oxygen. It is a treatment technique used to kill micro-organisms and pathogens in wastewater.

Pond

Ponds and lakes are artificial bodies of open water usually formed by a simple dam wall with a weir outlet structure. Typically the water depth is greater than 1.5m.

Potable water

Potable water is water suitable for drinking or ingestion purposes. It is assigned as potable on the basis of water quality standards. It is provided to householders through a reticulated (piped) water distribution network.

Process energy requirement

Process Energy Requirement is the energy directly related to the manufacture of a material.

Raingarden

Raingardens are constructed vegetation systems that filter polluted stormwater through a vegetated filter media layer. Water is treated, purified and released so it can flow downstream into waterways or into storage for reuse. Raingardens can often provide a habitat for flora and fauna.

Raingardens are also referred to as bioretention systems.

Rain water

Rainwater includes roof runoff and is generally stored in a rainwater tank.

Rainwater tank

A rainwater tank is used to collect and store rainfall from household roofs for reuse to provide a resource of non-potable water. They are of varying sizes and materials.

Reclaimed water

Reclaimed water is often used to define water recycled from treated sewage.

Recycled water

Recycled water is taken from any waste (effluent) stream and treated to a level suitable for further use, where it is used safely and sustainably for beneficial purposes. This is a general term that can include reclaimed water.

Recirculating media filters

Recirculating media filters (RMF) are made of two types – recirculating textile filters and recirculating sand filters. These are biological treatment processes removing organic material from wastewater. Textile filters are available in small compact package plants suitable for decentralised treatment.

Reforestation

Reforestation involves replanting an area with forest cover.

Reverse osmosis

Reverse osmosis (RO) is the finest membrane filtration process with the smallest pore size (estimated to be around 4-8 angstroms, or about the size of a molecule). RO has a high pressure requirement and therefore a high energy requirement too. RO can remove pathogens, viruses and salts.

Risk assessment

A risk assessment is the overall process of using available information to predict how often hazards or specified events may occur (likelihood) and the magnitude of their consequences (adapted from AS/NZS 4360:1999).

Rotating biological reactor

A rotating biological reactor is a type of biological treatment system that uses rotating discs to support active micro-organism growth which removes dissolved and organic matter from water.

Sedimentation

Sedimentation is a primary treatment process that removes pollutants through gravity settling. Sedimentation occurs at reduced flow velocities and thereby causes particles to settle. Sedimentation can occur in basins, tanks, ponds and wetlands.

Sand filtration

Sand filtration is an aerobic process where water percolates through sand. The principle removal mechanism is by straining where particles larger than the sand pore space are trapped.

Sedimentation basins

Sediment basins are used to retain coarse sediments from runoff. They are typically incorporated into pond or wetland designs.

Sequencing batch reactor

A sequencing batch reactor (SBR) is an activated sludge process where all the main treatment steps occur in the same reactor, including filling with influent, reaction, settling, drawing and decanting.

Sewage

Sewage (also called 'wastewater') is the human waste material that passes through a sewerage system. Sewage is much more than what gets flushed down the toilet. It also includes everything that goes down the kitchen, laundry and bathroom sinks as well as trade waste from industrial and commercial premises.

Sewerage system

Sewerage is the system of pipes and pumps that transport wastewater.

Water mining (or sewer mining)

Water mining or sewer mining is the process of extracting sewage from a sewerage system and treating it to produce recycled water for a specific end use.

Storm water

Stormwater is rainfall runoff from all types of surfaces. Stormwater is generated predominately in urban catchments from impervious surfaces such as like roads and pavements.

Suspended solids

Suspended solids refer to small solid particles which remain in suspension in water as a colloid or due to the motion of the water. It is used as one indicator of water quality. Particles can be removed by sedimentation or filtration.

Swale

A swale is a vegetated open channel designed to intercept and convey surface stormwater runoff, promote infiltration, and intercept sediment by the vegetation. It provides a landscape feature in urban areas.

Tertiary treatment

Tertiary treatment includes treatment processes beyond secondary or biological processes which further improve effluent quality. They are usually disinfection processes, sand filtration or membrane filtration.

Treatment train

The treatment train is a series of treatment measures to provide an overall approach to the removal of pollutants from water.

Trickle filter

A trickle filter is an aerobic fixed film biological reactor where water trickles over a bed of media to which the micro-organisms are attached (a biofilm).

UV disinfection

UV disinfection uses UV light to deactivate micro-organisms in water. The short UV wavelength destroys the genetic material of cells and stops it reproducing. UV has a low capital and operating costs and is well suited to small-scale water treatment processes.

Water balance

A water balance is a mass balance accounting for water entering, accumulating and exiting a system.
It includes rainwater, potable mains water, evapotranspiration and infiltration, wastewater and stormwater.

Wastewater

Wastewater is water which has been used for specific purpose and is no longer required or suitable for that purpose.

Water sensitive urban design

WSUD embraces a range of measures that are 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 surfaces), potable mains water (drinking water), greywater (water from the bathroom taps, shower, and laundry) and blackwater (toilet and kitchen) possess an inherent value.

Water reuse

Water reuse is the beneficial use of recycled water that has been treated for reuse on a site.

Wetland

A wetland is transitional area between land and water systems which is either permanently or periodically inundated with shallow water. Surface wetlands use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from water. Subsurface wetlands are a complex assemblage of water, soils, microbes, plants, organic debris and invertebrates where water flows through the soil. The soil is highly permeable and contains gravel and coarse sand.